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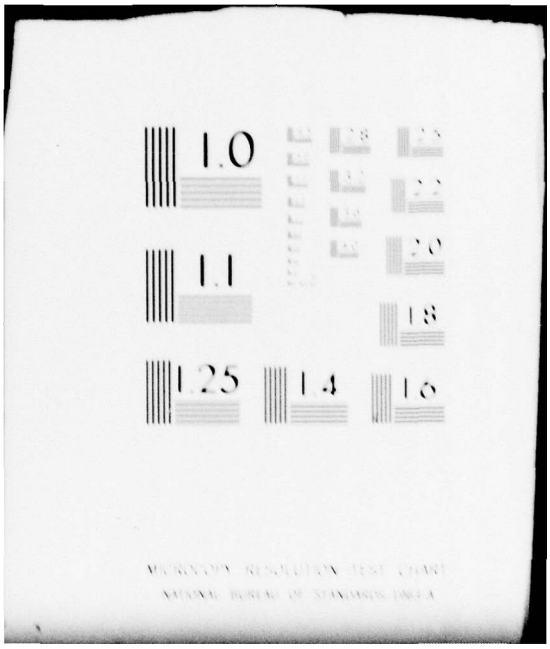
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IMPROVING THE PREVENTIVE MAINTENANCE CHECKS AND SERVICES PROGRAM FOR THE M60A1 MAIN BATTLE TANK

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LSSR 15-79B

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The major cornerstone of the Army maintenance program for the M60A1 tank is the preventive maintenance checks and services. One significant problem area is that the Army has not provided the maintenance manager with a usable systemic approach to planning and managing a viable, ongoing preventive maintenance checks and services program. The objectives of this research were to develop realistic time estimates for the individual tasks included in the preventive maintenance checks and services and to integrate those time estimates into a network model to be used for planning and monitoring the preventive maintenance checks and services. A network model of the scheduled service and individual task time estimates are presented along with the results of the survey questionnaire which was used in developing the network model and individual time task estimates. The conclusion of the research was that a viable useable maintenance planning model should be implemented to assist the maintenance manager. Recommendations and areas for further study are presented.

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IMPROVING THE PREVENTIVE MAINTENANCE CHECKS AND SERVICES PROGRAM FOR THE M60A1 MAIN BATTLE TANK

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

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This thesis, written by

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COMMITTEE CHAIRMAN

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CHAPTER I

INTRODUCTION

OVERVIEW

> The tank with its cross country mobility, its armor protection, and its formidable firepower, has been and is likely to remain the most important weapon of ground forces on the modern battlefield [20:1-2] .

The abilities and importance of the tank were well demonstrated in the Yom Kippur War of 1973 as one of the principal factors in the Israeli victory.

The M60A1 series main battle tank is currently fielded by all active United States Army armor units as the primary firepower weapon and serves as the backbone of the United States ground forces. The complexity of the M60A1 series main battle tank far surpasses any previous series of tanks in the Army inventory. Therefore, for optimum utility, it is an absolute necessity to establish and adhere to a responsive and comprehensive maintenance program. In order to insure that all items and subsystems work as an integrated system in the M60A1 series main battle tank, the Army has established a specific preventive maintenance checks and services system of scheduled maintenance services (21:2-43 to 2-58, 2-471 to 2-482). This comprehensive scheduled inspection and services involves an extensive list of inspection, service, lubrication, and repair items that address every aspect of each of the sub-

systems as well as the total tank as an integrated system. These services are performed at a minimum of every 90 days or 750 miles and are commonly known as the quarterly scheduled services (21:2-41).

Preventive maintenance services and checks on a quarterly basis for the M60A1 series main battle tank are a vital component of the maintenance system utilized by the armor battalions of the United States Army. To provide a better understanding of the framework within which quarterly scheduled services exists, an organizational structure overview is appropriate.

The basic armor battalion of the United States Army consists of five companies; a headquarters and headquarters company, three line companies, and a combat support company. The battalion is commanded by a lieutenant colonel. For planning, coordination, and supervision, the commander has an executive officer and a staff consisting of four principal staff officers in the rank of major or captain. Within this staff is the job position of battalion motor officer. The battalion motor officer works for and is rated by the battalion executive officer. His duties are to:

> . . . keep the commander and staff informed on the operational status of materiel and auxiliary equipment. He plans the battalion maintenance program and coordinates battalion maintenance operations with the direct support unit and other units as required. The motor officer supervises prescribed load lists, supply, recovery and evacuation of equipment, components and parts. He supervises the use of maintenance publications, scheduled preventive maintenance services, and training and licensing of equip-

> ment operators. He monitors and coordinates organizational maintenance operations, and maintains the equipment maintenance annex to the battalion standard operating procedures.... He plans the battalion maintenance training program and leads the battalion maintenance platoon [18:2-5].

The battalion motor officer is essential to the armor battalion if a working maintenance program is to be established and maintained.

The automotive maintenance technician, who works directly for the battalion motor officer, is a warrant officer normally in the grade of WO1 or WO2. His principal role is to act as the technical supervisor of the maintenance work and chief advisor to the battalion maintenance officer.

The battalion maintenance platoon is part of the headquarters and headquarters company. This platoon is headed by the battalion motor sergeant and has as integral parts a recovery section for the recovery and/or evacuation of disabled vehicles; a section of track vehicle mechanics; a section of power generation equipment mechanics; a section of tank turret repairs mechanics; a section of allied trades personnel; and finally, clerical records personnel. Below the battalion level maintenance structure there is a company level maintenance structure which is similar to the battalion maintenance platoon but smaller in size. The number of these personnel fluctuates depending on the type armor battalion and manning requirements, but their function is basically the same regardless of the manning level.

Mechanics at the organizational level (battalion and company) perform organizational maintenance and repair work on organic vehicles and other equipment as defined in appropriate maintenance allocation charts, standard procedures, and in guidance from the motor sergeant. Their training and capable maintenance abilities are another vital component of a viable maintenance program. The principal maintenance management responsibility at the organizational level is the efficient use of the assets of time and personnel in reaching organizational maintenance goals.

PROBLEM STATEMENT

The problem for research is that there is a need to accurately estimate time requirements of scheduled services and to assess the suitability of the application of network analysis to scheduled services. Symptoms of this problem include the lack of useful management tools or ideas for the armor battalion's present scheduled service program. Another limitation of the current maintenance environment is the newly assigned organizational level maintenance manager's inability to quickly evaluate his scheduled services capabilities.

JUSTIFICATION

As the main firepower weapon of United States Army armor units, the M60A1 main battle tank must be kept at a high operational ready rate to help insure national defense

both abroad and at home. The crux of a high operational ready rate for equipment of any type is a well established preventive maintenance program, or as General W.C. Westmoreland, former Chief of Staff of the United States Army so succinctly said:

> The United States Army is a highly mobile, hard hitting, combat-ready force that must respond quickly to any emergency in support of our national objectives. Critical to maintaining the Army's combat readiness is the quality and timeliness of the maintenance performed on its equipment - especially in the current austere environment of diminishing resources [18:Forward] .

The limitations on time and resources necessitates integrative planning for all aspects of armor units. Therefore, it is essential that the quarterly scheduled services, an important part of the preventive maintenance program, be integrated with the overall training program and that maintenance time devoted is planned and utilized as efficiently as possible.

A well managed quarterly scheduled services program helps to improve crew training objectives. The ability to train an effective tank crew is directly related to the availability of that crew's assigned tank. Within the armor crewmen military occupational specialties, there are few tasks, conditions, and standards of training that do not incorporate the vehicle or for which a simulator can be effectively substituted. A well managed quarterly scheduled service program can also detect and repair minor deficiencies before those deficiencies result in lower availability. This program, when combined with effective trouble shooting, can also reduce cost

by proper lubrication and repair/replacement of minor components instead of replacing costly major assemblies. Finally, a well managed quarterly scheduled service program can assist in training mechanics. Quarterly scheduled services are easily adapted into the current United States Army training philosophy of providing a task, condition, and standard.

RESEARCH OBJECTIVES

The research objectives of this study were:

1. To identify organizational items that affect M60A1 tank scheduled service times;

2. to determine optimum time estimates of accomplishing each of the tasks included in the M60A1 tank scheduled services; and

3. to construct a suitable network model for integrating scheduled services of the M60A1 tank into the most efficient and effective program possible.

RESEARCH QUESTIONS

1. Can accurate time estimates for individual task accomplishment in the scheduled services of the M60A1 tank be established by use of input data from field units?
2. Can a network analysis system be developed to assist organizational level maintenance managers in planning and performing quarterly scheduled services?

CHAPTER II

LITERATURE REVIEW

INTRODUCTION

The United States Army policy on the overall program of preventive maintenance has far-reaching effects for all materiel within its inventory. Therefore, the problems of effecting a working preventive maintenance program have been studied extensively from many aspects. In the past, the scheduled services aspect of this program has been somewhat accepted as a stable system which has little variation in management techniques. Unfortunately, there is minimal research in the area of improvement of management techniques or in the actual scheduling of the services required on the M60A1 main battle tank. Within this chapter the discussion will attempt to cover general maintenance concepts, network analysis concepts, and scheduled services concepts as applicable to the thesis research topic.

GENERAL MAINTENANCE CONCEPTS

Maintenance management has been defined as: " . . . management of those assets required to sustain equipment in a state of operational readiness consistent with the demands of the chain-of-command [19:2-10] ." The Army maintenance system is founded on a three-pronged philosophy which holds:

(1) Maintenance is a common responsibility beginning at the unit level.

(2) Maintenance is to be accomplished at the lowest level consistent with the tactical situation and the skills, tools, and test equipment, time, and repair parts available.

(3) The unit commander must have a reliable and responsive maintenance source upon which he can depend when maintenance actions are beyond the scope of his responsibilities [4:11] .

This philosophy is built on the following assumptions:

(1) Each and every element of the maintenance organization is competent and present as needed.

(2) Maintenance is an ongoing program that stays within scheduling tolerance.

(3) Required parts are available when required or shortly thereafter (5:12-13).

These assumptions may not be valid given current manning levels, level of experience, training requirements, long lead time for procurement, and lack of efficient maintenance capability engineered into some weapon systems. The managerial philosophy for a maintenance manager requires a perspective that is broader than that of other managers at the same level. This perspective must include the constraints imposed on the resources of training time, human resources, and operating funds.

The objectives of this philosophy have been generally accepted to be as follows:

(1) To extend the life of equipment through timely repair, and an ongoing preventive maintenance and scheduled

maintenance program. This area when coupled with an effective modification program provides for efficient use of funds. The high cost of replacement equipment and new acquisition programs provides this objective with the most potential for cost savings within tne maintenance management arena (6:3).

(2) To assure operational readiness of equipment in accordance with established standards of Department of the Army and Department of Defense. In terms of the world political situation, this objective is the most critical (6:3).

(3) Provide commanders at various levels and Department of the Army and Department of Defense the information for effective decision making (5:13). This area at present provides for tne most advances in decision making based on the development in recent years of the high speed electronic computer and data storage and retrieval systems.

This discussion of the general scope of maintenance concepts and philosophy has been limited to the Department of Defense because of the different environment for which the military must design and maintain its equipment as compared to civilian industry. All further discussion in this thesis will be developed with the Department of Defense as focal point of research and the intended receiver of any useful results.

Encumbent upon the maintenance management system is the necessity of continually searching for ways to improve the system. The next topic of discussion, network analysis

techniques, might provide managers with the ability to effectively integrate technical aspects of maintenance with Department of the Army preventive maintenance objectives.

NETWORK ANALYSIS

The tremendous increase in cost that has occurred in the years since World War II has led to more efficient methods of controlling and managing complex systems. One of the methods developed to deal with the problems of managing complex systems is network analysis. Although network analysis is a powerful management tool, it suffers from one of the problems that face most managers in their day-to-day decision making; namely, the accurate estimation of activity time. Inaccurate time estimates can negate an otherwise well designed network (2:114).

Hershauer and Nabielsky suggested the following nine climates for estimating activity times:

1. certainty--same activity.
2. certainty--similar activity.
3. risk--mode and range only.
4. risk--common distribution.
5. objective risk.
6. subjective risk.
7. uncertainty--mode only.
8. uncertainty--range only.

9. subjective uncertainty (9:17-18).

The first and second climates can be estimated with a high degree of accuracy using point estimation. This is a result of the repetitive nature and the ability to collect historical data to assist in arriving at a point estimate.

The remainder of the estimation climates require that time estimates be arrived at more subjectively. The application of statistics can greatly improve the accuracy of these estimates. In addition, Burman suggested several ways to minimize errors in estimating accuracy:

1. Estimates should be made on an individual activity basis. Delays should not be considered.

2. Normal enviornment should be emphasized.

3. The estimate should reflect project conditions.

4. Randomly select activities to estimate. If a chain of activities is attempted, the person making the estimates may unconsciously add up estimates which may influence further estimates.

5. When collecting optimistic, pessimistic, most likely estimates, collect the optimistic and pessimistic first. This limits the time interval and leads to a better "most likely" estimate.

6. Allow for activities that are not usually measured in man-hours or workdays; i.e., concrete curing.

7. Estimates must clearly reflect the efficiency

factors taken into account; for instance, whether or not a journeyman or an apprentice was used in estimating.

8. Apply efficiency factors to the activity only and not to the project as a whole.

9. Obtain written estimates from subcontractors rather than estimating (3:84).

Often the person developing the network does not have the technical competence to accurately estimate each activity. In these cases, the planner must depend on others to provide estimates of activity time. The potential planner should consider the following aspects:

1. Accuracy is dependent on the experience of the person and type of work (1,3).

2. No attempt should be made to apply universal solutions (1).

3. Learning curves in estimating have not been identified and are probably project dependent if they exist (1).

4. Long activities should be subdivided to reduce error probabilities (3,9).

Network analysis could be a useful tool for the organizational maintenance officer. The next area of discussion, scheduled services, suggests one area to which network analysis could be applied to improve management control of an organization.

SCHEDULED SERVICES

Scheduled services can be defined as follows:

> . . . that type of maintenance which inspects, adjusts, repairs or replaces equipment on an economic basis at calculated intervals before failure could force an emergency shutdown [10:101,102].

Scheduled services have not fully benefited from available management techniques. Lewis and Tow presented the following reason:

> As mechanization increased during the sixties, industry in the United States became aware of the mistakes of inadequate planning for maintenance. Although great advances were made in the engineering profession, few new ideas materialized in the field of maintenance. Many of the methods used today have not changed from the haphazard, ineffective, and expensive procedures of the 1930's [10:102].

Current military doctrine emphasizes the importance of timely scheduled services (17:6-10; 18:7-1). Although the military services emphasize the importance of scheduled services, there has been little research done on improving the maintenance manager's ability to monitor and manage scheduled services. In regards to the M60A1 tank, the United States Army Armor School at Fort Knox, Kentucky has developed a flow chart of maintenance activities for the quarterly scheduled services (16). The research data resulting in the flow chart model has not been located and validity of the flow chart model cannot be verified. In addition, the flow chart is deterministic and has little ability to adjust for variations within units.

RELATED STUDIES

A closely related 1976 study concerning scheduled services called Project LEAP was done by the United States Army Maintenance Management Center located at Lexington-Blue Grass Depot in Lexington, Kentucky. Each commodity command in the Army organization structure tested at least one of its major end items for possible savings by reduction of the preventive maintenance checks and services. The Tank-Automotive Readiness Command chose three end items, one of which was the M60A1 series main battle tank. (15)

The results of the study showed that the M60A1 tank preventive maintenance checks and services were reduced from 93 checks to 44 for a total 52.7 percent reduction in the checks that were done. The manhours per year was reduced from 125.78 to 20.41. Using a rather complicated formula for manhours, the Tank-Automotive Readiness Command estimated a savings of $840.87 per tank per year. The tanks tested travelled an average of 534 miles per year and were operated under normal conditions. (15)

The Tank-Automotive Readiness Command recommended to the Army Maintenance Management Center that the program be implemented based upon the results of the three vehicles that were tested. However, the Tank-Automotive Readiness Command also suggested that before implementation, each type of vehicle should be evaluated separately before being instituted into the

program (15:42). The program is still pending final action.

SUMMARY

The literature review of the background of scheduled services as part of the preventive maintenance program has indicated general agreement with the importance of scheduled services. However, very little managerial application of science seems to be directed towards improving the methodology or techniques of scheduled services. The literature review has attempted to bring out the basic concepts of maintenance necessary to help understand the framework within which scheduled services must be performed. Network analysis and scheduling techniques were discussed because they are tools which might be utilized by management to improve the scheduled services program.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

INTRODUCTION

The purpose of this chapter is to outline the research design and methodology used in this thesis. To fulfill this purpose it was necessary to: define the population which was being studied; outline the experiment being conducted, delineate the variables of the experiment; describe the method of collecting the data; delineate the data analysis techniques utilized; and finally to describe or discuss the assumptions and/or limitations that circumscribed the area of experimentation.

DESCRIPTION OF POPULATION

The population of units having the M60A1 Tank consists of United States Army Armor units, Cavalry units, Reserve units, National Guard units, and some foreign allies. The number of active duty armor battalions having the M60A1 Tank is 41. These 41 battalions were the primary data producing population. United States Cavalry units are currently converting from the M551 Sheridan Airborne Assault Reconnaissance Vehicle to the M60 series tank, and thus were purposely excluded since it was felt the base of experience

to estimate times of task completion would be somewhat limited. It was also felt that the environment under which the active duty unit operates, its usage factors, and the personnel stability aspects were each appreciably different from that of the non-active duty units and could cause discernible differences in the time estimates of performed functions in the questionnaire. Therefore, non-active duty armor units were purposely excluded, and the data producing population were stratified to active duty armor battalions only. Since the organizational environment, the personnel, and the technical support are similar, the data produced from these sources should be representative of all units possessing the M60A1 tank.

INSTRUMENT OF DATA COLLECTION

Method of Data Collection

The instrument of data collection chosen for this thesis was a mail questionnaire (see Appendix A). This method of data collection allowed the researchers to sample a large and unbiased population. Since the population of research spanned worldwide, the mail questionnaire was chosen considering fund constraints on travel and time availability for research. Other likely methods such as telephone surveys or personal interviews were ruled out in an effort to conduct

the research as efficiently and effectively as possible.

Questionnaire respondents returned it directly to the researchers. Specific unit response was anonymous. However, the design of the questionnaire itself (question one) allowed the researchers to develop information or trends about major commands.

Respondents were encouraged to reproduce copies of the research questionnaire for their own information and instructional use. Additionally, each respondent was given the appropriate information on how to obtain the completed report.

Individual Question/Variable Evaluation

To aid in understanding the questionnaire, each of the integral parts will be discussed. Section one of the questionnaire (pages 1 thru 3) was to be used to obtain information on the independent variables which were in turn to be used in conjunction with time estimates to develop a regression model for determining the time estimates for the individual checks and services in the preventive maintenance checks and services system. Other questions in section one were used to develop information on scheduling that can be of use to the armor maintenance officer in developing a viable

maintenance program. Section two of the questionnaire (pages A-1 thru D-1) was used to gather the time estimates for the individual checks and services. Section three of the questionnaire was used to obtain information on the respondents perception of the network relationships of the preventive maintenance check and services. Each of the following sub-sections discusses more fully the questionnaire, and each contains the justification for individual items in the questionnaire, identification and use of variables, and the data level of the responses.

Question one. Major command was to be used as one of the independent variables in developing the regression model for determining times to perform the individual checks and services. It was assumed that because of differences in priority issue designators, the ability to obtain the necessary repair parts more rapidly will affect time estimates from the various major commands. The measurement scale of question one is nominal. The data level is discrete limited.

Question two. Maintenance experience was to be used to determine if experience level was a significant predictor of time. A strong correlation between maintenance experience and the time estimates with the effect of the other variables removed made the validity of the data from respondents with low experience

levels questionable. The measurement scale of question two is ordinal. The data level is discrete limited.

Question three. Maintenance experience level of the respondent's present unit was to be used as another of the independent variables in developing the regression model. Experience level of the maintenance personnel was assumed to be related to the time estimate to perform a specific check or service. The measurement scale in question three is ordinal. Although the number of responses in the questionnaire may be very limited, it was felt that the scale presented was as effective as an interval scale such as average years of experience, and in addition is the type of subjective judgment that an incoming maintenance officer would be able to make quickly and effectively when evaluating a maintenance platoon. Therefore, the measurement scale was treated as interval. The data level is discrete limited.

Question four. Experience level of the tank crews in the respondent's present unit was to be used as another of the independent variables in developing the regression model. Experience level of the tank crews was assumed to be related to the time estimates to perform a specific check of service because of the integration of the tank crew into the scheduled services program. The measurement scale and responses may be considered limited in choice, but these are the type of eval-

uations made by a maintenance officer when evaluating a maintenance program. The measurement scale was treated as interval. The data level is discrete limited.

Question five. Average age of the tanks in the respondent's unit was to be used as another of the independent variables in the regression model. As a vehicle grows older, it is assumed to require more time to detect and repair deficiencies and thus increase the time estimates to perform individual checks and services. The measurement scale in question five is ordinal because of the ability to establish an absolute zero point and the ability to make ratio statements about the relative ages of tanks. The data level is discrete limited.

Question six. The number of tanks that are started through a service simultaneously was used in conjunction with the data from question fourteen to develop recommended scheduling guidelines to assist the maintenance officer in developing an effective, viable maintenance program. The measurement scale in question six is interval. The data level is discrete multiple.

Question seven. The number of working days to service what the respondent considers to be a feasible number of tanks was used in conjunction with question six and fourteen to develop recommended scheduling guidelines. In addition, the data from question seven was compared with the compiled normal

times from a unit to determine if the number of working days can reasonably be achieved using the units normal time estimates. The measurement scale in question seven is ratio. The data level is discrete multiple.

Question eight. Constraints caused by facilities were to be used as another of the independent variables in the multiple regression model. This question may or may not prove to be a reliable regressor becaused of the subjective nature of the answers; however, the researchers believed that the efficiency, and thus the time estimates, of scheduled services were affected to some degree by facilities. The measurement scale of question eight is ordinal. The data level is discrete limited.

Questions nine thru eleven. These questions were intended to survey the attitudes and perceptions of the respondents concerning the scheduled service system in its present state. The tabulated responses represent the field's view of which direction the Army's philosophy of management of scheduled services should take. The measurement scale of questions nine and eleven is ordinal and ten is interval. The data level is discrete limited.

Questions twelve and thirteen. These questions on an advanced inspection and lead time for Class IX (repair parts) were tabulated and correlated to provide recommendations on advanced

inspections based on lead time for Class IX. This type of recommendation should assist the maintenance officer in conducting his pre-planning to prevent poor utilization of time scheduled for scheduled services because of Class IX shortages. The measurement scale in these two questions is ratio. The data level is discrete limited.

Question fourteen. The system of scheduling tanks was used in conjunction with questions number six and seven to develop recommended scheduling guidelines to assist the maintenance officer in developing a viable maintenance program. To prevent bias, responses were not provided. After the questionnaires were returned, the responses were divided into like cells to ease the compilation and the calculations involving this question. The measurement scale of question fourteen is nominal.

Question fifteen. The current condition of the tanks in the respondent's unit was to be an independent variable used in the regression model. It was assumed that there is a relationship between mechanical condition of a tank and the time to conduct an individual check or service. The measurement scale of question fifteen is interval. The data level is discrete limited.

Question sixteen. Information on the composition of scheduled service teams was compiled to provide recommendations to the maintenance officer on the composition of a scheduled service

team. The measurement scale in question sixteen is nominal.

Question seventeen. Information on shifting responsibilities was checked to see if units shift responsibility and if there was a detectable pattern in shifting of responsibility. The measurement scale in question seventeen is nominal.

Question eighteen. Information on updating of logbooks was compiled and used in the network model. At present, this important component of a maintenance program is excluded from the scheduled service checks and services. The measurement scale is nominal.

Question nineteen. Opinions concerning the need for a quarterly scheduled service in its present form was compiled and represented possible changes which were recommended for the scheduled service as it now exists.

Question twenty. Data received from units that have other than M60A1 series vehicles were screened to remove time estimates for those checks and service that were not compatible with the M60A1. The number of tanks was totaled to provide information on the percentage of M60A1 tanks in the active duty inventory that was included in this research effort. The measurement scale in question twenty is ratio. Data level is discrete infinite.

Question twenty-one. Self explanatory.

Sections A thru D. This section of the questionnaire was used to collect the time estimates for the individual checks and services. The times collected were the pessimistic (LOT), the optimistic (LET), and the most likely (NOT) time estimates. The times for each check and service were averaged to form a general stochastic network model. The times were also to be used as dependent variables in the multiple regression model to provide times estimates for a network model that was tailored to a particular unit situation based on responses to the independent variables. The measurement scale of these sections is ratio. The data level is discrete infinite.

Section E. This section of the questionnaire was used to obtain opinions on the precedence relationships involved in the preventive maintenance checks and services. A bias may have been introduced by providing a completed network for comments, but no alternative solution could be found for obtaining the necessary data from respondents who may not have been familiar with network analysis. This section was reviewed and changes made to the basic network based on valid comments from the respondents.

Instrument Validity

One of the critical elements in the decision to use a questionnaire as a data collection instrument is whether it will measure what it is designed to measure. The two general

forms of validity generally mentioned in research literature are internal and external validity (7:120). Internal validity is a measure of how well the parameters of the instrument itself perform their intended function.

The internal validity of this questionnaire was strengthened by the screening completed by faculty members of the School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson Air Foce Base, Ohio and the M60 Tanks Project Manager Office, Warren, Michigan. Additionally, the Military Occupational Development Center, Military Personnel Center, Alexandria, Virginia has also reviewed the questionnaire for appropriateness and validity in conjunction with assignment of a United States Military Personnel Center survey control number.

Individual question validity is perhaps somewhat less assured. The use of a questionnaire created specifically for a new area of research has the unique problem of few precedence setting guidelines. However, questionnaire validity can be enhanced by carefully designed research and the use of available expert resources as has been done in this case.

Emory offered three other measures of internal validity: content, criterion-related, and construct (7:120). The most pertinent of these to this research is that of criterion-related validity. Criterion related validity "reflects the success of measures used for some empirical estimating purpose [7:121] ."

Thorndike and Hagen distinguish this even further by establishing four categorical qualities criterion: relevance, freedom from bias, reliability, and availability (8:168).

A criterion is relevant if it is defined and scored in the terms judged to be a proper measure of success (7:122). In this questionnaire this could be defined to mean that the questionnaire or its end results are useful to the audience for which it was designed. This idea was generally verfiable by the fact that the M60 Tanks Project Manager Office had indicated that the results of the questionnaire could impact on the respondents in a favorable sense.

The second criterion, freedom from bias, means that equal chance exists for each member of the population to complete a questionnaire (7:122). This was partially fulfilled in this research since the stratified population included all active duty armor units. Those units owning M60A1 tanks that were excluded, were done so to eliminate unusual bias.

The third quality is a reliable criterion which denotes that a criterion is stable or reproducible (7:122). The fact that all active duty armor units were surveyed lent credibility to the reliability aspect being fulfilled. Since all armor units are based on the same United States Army maintenance policies and other doctrinal positions, it follows that the units should be homogeneous in nature.

The final measure of criterion is that of availability.

In the case of this research, the information was readily available and required no further investment of time or cost since the service investigated was one that is required by a regulatory statute and performed on a periodic basis.

The second general classification of validity is external validity. Campbell and Stanley address external validity as follows, "External validity asks the question of generalizability: To what populations, settings, treatment variables, and measurement variables can this effect be generalized [4:5] ?" External validity is a direct contrast to internal validity since it is concerned with the influence of external factors on parameters of the data collection instrument.

One of the common problems of external validity is the sensitization of the sample population by means of some type of pre-association with the research content which could bias the reaction to the final data collection instrument (7:305). Since there was no previous association or pre-surveys with the sample population in this research, this type of problem was of little consequence to the validity of the proposed questionnaire. To enhance the validity of the questionnaire, the researchers followed-up the mailing of the questionnaire with a personal telephone call to stimulate interest.

The major problem area of external validity is that

of erroneously inferring the results of the sample population to the general population (7:305). In this case of research the organizational environment, the personnel, and the technical support were similar for the entire population. Also, since the questionnaire centered around one specific aspect of a single item of equipment common to the entire population, the data produced was representative of all units possessing the M60A1 tank.

Instrument Reliability

"The tendency toward consistency from one set of measurements to another is called reliability [13:356] ." Normally the extent of reliability is measured quantitatively in terms of degree of correlation of like samples. When reliability is considered in questionnaire response, its meaning is virtually the same. Researchers are normally interested in the difference or variance between separate questionnaire responses and the resulting estimate of reliability for individual questions as well as the overall instrument reliability.

The typical reliability verification is usually done by the test-retest method. Since the questionnaire for this research was created specifically for a one time compilation of data, the questions had not been previously validated. Until such time as a like questionnaire could be distributed,

the reliability of this questionnaire as the instrument of data collection must be accepted.

STATISTICAL TECHNIQUES

The design of the statistical techniques should be considered prior to the actual receipt and compilation of the data. Since each variable has been covered in detail in the "Data Collection Instrument" section, this discussion addresses overall methods of statistical techniques used.

The intent in the original development of the questionnaire was to develop time estimates for scheduled service tasks and to use those time estimates to develop a network system by which an armor battalion motor officer could establish and conduct a scheduled service program. In consonance with those objectives, a multiple regression model was to be established which considered variables 1-5, 8, and 15 within section one of the questionnaire. The intent of such a model was to allow a unit motor officer to evaluate his unit utilizing the independent variables established in this study and then to have that data induced into a computer program which would compute and print out an individualized stochastic network model. The statistics of creating this effect was simple in description but complex in actual design and program construction. Each section of the statistics utilized is briefly described and listed below.

The first statistics developed were the descriptive statistics which includes computation of mean, mode, median standard error, and standard deviation for the longest expected time, the normal expected time, and the least expected time for each of the 93 tasks involved in the scheduled services and for background information questions 1-13 and 15. These values were the basis for efficiency recommendations and the generalized stochastic network model that was developed. The program to compute this data was drawn from the Statistical Package for the Social Sciences (11:181-202). Further refinement of these descriptive statistics provided confidence intervals for the variables and time estimates. A Q-GERT program was used to develop the times for the stochastic network model.

To establish an individualized stochastic model required the use of an advanced statistical method known as multiple regression. "Multiple regression is a general statistical technique through which one can analyze the relationship between a dependent or criterion variable and a set of independent or predictor variables [11:321] ." The purpose of using multiple regression in this case was to be threefold. First, it was to allow the researchers to evaluate stratified data and to infer the results to the general population given that certain model assumptions were satisfied. Second, it was to allow efficient handling of a large volume of data. Third, it was to organize

this large volume of data into useful management information.

Since the multiple regression model requires numerous tedious computations, it was well suited to adaptation to the computer. Building specific programs for this research was not necessary since the Statistical Package for the Social Sciences (11:320-367) offered prepackaged programs for multiple regression analysis.

Utilizing these prepackaged programs, the researchers established a multiple regression model in the following manner. Using PERT methodology for computing most likely times, each questionnaire estimate for each of the optimistic, pessimistic, and most likely completion times of each of the ninety-three tasks in section A thru D was combined as the dependent variable and selected variables in section one as the independent variables in the regression model.

Statistical Assumptions

The statistical assumptions required by the multiple regression model provide the most stringent requirements of any of the statistics discussed. Since any assumptions required for nonparametric tests and descriptive statistics are included in the assumptions for multiple regression, all assumptions will be discussed as multiple regression assumptions.

1. The first assumption was that e_i ($e_i=Y_i-Y$) is independent. This means that no pattern can be determined as the dependent variable assumes different values. If e_i is not independent

then autocorrelation exists.

2. The second assumption was that the expected value of e_i is equal to zero.

3. The third assumption was that the variance of e_i is equal throughout the range of Y values.

4. The fourth assumption was that e_i approximates a normal distribution.

5. The fifth assumption was that the number of observations must be greater than the number of parameters. This prevents the case where the degrees of freedom is equal to zero.

6. The final assumption was that the independent variables have been observed without error.

NETWORK CONSTRUCTION

After time estimates for each check and service had been established using the more generalized averages, the next step was to develop the network model. The first step in developing the network model was to examine the precedence relationships that exist in scheduled services. Section E of the questionnaire presents a network model, the comments from the questionnaire respondents were incorporated into that model.

The second step in establishing the network was to determine which checks and services could be better managed as groups rather than as individual checks and services.

This affected the number of activities in the network.

The third step was to compute the average time and draw out the network using the precedence relationships and average times. The formula to compute average time is $t_e = \frac{t_o + 4t_m + t_p}{}$ where t_e is the average time, t_o is the optimistic time, or least expected time; t_m is the most likely time, or normal time; t_p is the pessimistic time, or longest expected time (14:252).

The fourth step was to compute the earliest expected completion time that the project can be completed, and the latest expected time. From this information, the critical path through the network was computed. This information allows the manager to concentrate his efforts on the activities on the critical path. Finally, the variance of the activities was computed and used to provide management information on completing the scheduled service in a desired time (14:255). The results for the scheduled service network were derived using Q-GERT.

Q-GERT is a computer assisted modeling/simulation tool that has its basis in the network approach to modeling (12). PERT and CPM provide an excellent base for understanding the concepts involved in Q-GERT. When working with PERT or CPM, the following characteristics must be met: (1) It must have well-defined jobs or tasks whose completion marks the end of a project. (2) The jobs or tasks are independent in that they

must be started, stopped, and conducted separately within a given sequence. (3) The jobs or tasks are ordered in that they must follow each other in a given sequence. (4) A job or task, once started, must continue without interruption until completion. When these assumptions are met, they tend to restrict the richness and variability which are involved in the real life situation, the only one of these assumptions that must be met using Q-GERT is number one which requires well defined jobs. The reduction in restrictive assumptions allows a model utilizing Q-GERT to maintain many of the characteristics of the real life situation.

In the following section, some of the fundamental concepts of Q-GERT are discussed and illustrated. The first concept discussed is that of queue formation. Wherever one cares to look, lines can be seen forming to obtain gas, cash a check, buy groceries, or use a public service. This concept is also applicable in industrial and manufacturing applications where parts await machining or customers are waiting for a finished product or service. Q-GERT utilizes a Q-Node which allows transactions to wait in line to obtain a service. The modeler can specify the initial number in the node, the maximum capacity and the type of branching from the Q-Node. An important capability of Q-GERT is the capability of a transaction to balk when the queue reaches a certain length. Often

in real life when we encounter a line, the decision is made to balk out of that line. With Q-GERT, the balking transaction can be returned to the Q-node later, can be routed to a different location or allowed to leave the system totally.

Another important concept of Q-GERT is that of attributes. Attributes can be considered characteristics of a transaction moving through the system. A transaction models whatever might flow through an induction center, demands on a supply system or cars on an assembly line. In the examples just given, people, demands, or cars have different characteristics which individualize them. Q-GERT allows the modeler to assign up to one hundred characteristics or attributes to a transaction; these attributes can be used as a basis for routing through the system being modeled.

Q-GERT also provides the user with ten of the classical statistical distributions for modeling activity length or assignment of attributes. In addition, random number generation is available plus a user function which allows the user to build very situational activity distributions or logic branching. This capability provides excellent flexibility not available in PERT or CPM models.

A final important concept is that of resources. Often real life situations are constrained by a finite number of available resources such as manpower, machines, flight hours or dollar limitations. Q-GERT provides for a resource pool

which can be limited to real life levels. The resources capability allows the modeler to more accurately assess a system which is constrained by a resource.

In summary, Q-GERT allows the flexibility to effectively model complex, dynamic systems which abound in the world around us. The speed and ease with which a real life system can be modeled and then changed as needed provide the manager with the ability to prod and poke at a model of his particular system realistically without suffering the possible consequences of tampering with the real system. In this way, effective decisions can be made at a relatively low cost and with minimal risk as compared with a subjective decision based only on the gut level feelings of a manager.

LEVEL OF SIGNIFICANCE

The 0.05 level of significance is widely used in management research. However, due to the unproven reliability of the instrument of data collection and the originality of the questionnaire itself, the absolute rejection of results at the 0.05 level seemed inappropriate. Therefore, the significance level for all tests was calculated in probability value figures so that the reader could assess the exact figure rather than merely the fact that a value is significant or not significant at some level. However, the researchers realize that there must be some reasonable cut off for results to be

usable and considered a significance level of 0.10 to be more in line with the exploratory nature of the research.

CRITERIA TEST

The most feasible criteria tests to apply to the statistical results would be the criteria test that the commander of an armor unit would apply to the quarterly service program in his particular unit. From the researchers' personal experience, this criteria test is the quality level of the scheduled service received for the time alloted to the scheduled service. Since no attempt had been made to establish varying quality levels in this thesis, it is assumed that the quality level of the scheduled service was high and that the length of a scheduled service was an efficient measure of a scheduled service based on the variables of equipment condition and the experience level of the mechanics and tank crews involved.

The specific criteria that was applied in this thesis was a subjective view of the individual normal times of the checks and services and the most likely time for the total service. Interviews of armor unit commanders in the field were conducted to determine if the times determined from the model would be acceptable considering their unit's equipment condition, experience level, and training requirements.

ASSUMPTIONS

The general assumptions under which this research was conducted were as follows:

1. The stratified sample of active duty armor battalions was representative of the total population.
2. The instrument of data collection was valid and reliable.
3. The statistical tests to be used were valid and reliable.
4. The level of significance chosen was reasonable.
5. The approach of a stochastic network model in scheduled services was reasonable and usable in armor units.
6. The quality of scheduled services performed was uniform throughout the unit surveyed.

LIMITATIONS

1. The use of an untried and unproven data collection instrument limited the assessment of the validity and reliability of the overall model to be used.
2. The research time and funds limited the depth of the research.

CHAPTER IV

DATA ANALYSIS AND INTERPRETATION

INTRODUCTION

The purpose of this chapter was twofold. First, the researchers analyzed the massive amounts of data that were generated from the questionnaires and the computer programs used to consolidate that data. Second, the researchers interpreted the results of that analysis and attempted to assimulate the data into usable information to fulfill the original research objectives of this thesis.

MULTIPLE REGRESSION

After compiling times for individual tasks of quarterly preventive maintenance checks and services, and an overall time for a complete quarterly service, an individualized service model was considered. A review of the general model for the complete quarterly service showed that on the average only 12-15 hours of variance existed; therefore, the researchers believed that the benefits gained from an individualized multiple regression model were not adequate to justify it's development.

DATA PROCESSING AND ANALYSIS

Survey Response

After it was determined that 41 units existed that owned and maintained the M60A1 tank as the primary weapon system, the survey shown at Appendix A was sent to each of those units. The intial response was fair with 21 surveys returned by 15 April 79. Since the units were allowed to remain anonymous if desired, five units of the total 21 chose to do so. In order to send out follow-up letters, it was necessary to send letters to 25 units which resulted in duplication to the anonymous five units. As an added prompting, telephone requests were made to those same 25 units. The end results of these efforts were 10 more survey returns for a total of 31 surveys received out of a total number mailed of 41. Since statistical analysis required 30 surveys returned in order to fulfill the Central Limit Theorum requirements, the required goal of 30 had been exceeded.

Profile of Survey Demographic Information

The original intention of the demographic information was to help develop a multiple regression model. Even though it was decided by the researchers not to use the multiple regression model, information within certain questions was of importance in adequately describing the sample population.

Appendix B shows the results of each of these items for general information about the survey respondents and their units.

Raw Data Base Explanation

Since the survey was designed to be analyzed by computer, it was necessary to develop a simple way of accumulating all of the data on one file. It was also important that data could be added to the file as questionnaires were returned to the researchers. The file had to be manipulative in order to draw certain parts or all of the data as needed for different computer programs.

A suitable and relatively simple file that accomplished all of the above needs was the freefield file. In this particular file, there were 201 bits of data to be used from the questionnaires. Therefore, a freefield file of consecutive surveys each containing 201 bits of data was used. Survey items one through 6 correspond to freefield positions one through six. Survey item seven corresponds to freefield positions seven and eight. Survey items eight through thirteen correspond to freefield positions nine through fourteen. Survey item 15 corresponds to freefield position 15. Survey items one through forty-three, section A; 44 through 68, section B; one through twelve, section C; and D01 through D11, section D correspond to freefield positions 16 through

108. Suggested frequencies of performing each of the individual tasks corresponds to freefield positions 109 through 201. The actual raw data base utilized is listed in Appendix C.

CONDESCRIPTIVE STATISTICS FOR TIME ESTIMATES OF INDIVIDUAL TASKS

Individual time estimates were compiled using the condescriptive subprogram of SPSS (11:185-190). The program used is shown in Appendix D, section one. Table 4-1 shows the individual tasks, mean time estimate, minimum time estimate, maximum time estimate, and the standard deviation of the estimate.

DESCRIPTIVE STATISTICS

Analysis of Survey Questions Affecting the Ability to Perform PMCS

The questions discussed in this section dealt mainly with the abilities, and the items that affected those abilities, to perform PMCS. The general format of the discussion will: first, show the item and available answers as listed in the survey; second, show the computer compiled results with histogram; and third, a general discussion/analysis of those results. The program used to compile these statistics was the frequencies subprogram of SPSS (11:194-201) and is shown in Appendix D, section two.

Question six. How many tanks does your maintenance facility

TABLE 4-1

TIME ESTIMATES OF INDIVIDUAL TASKS
(MAN HOURS)

TASK	MEAN	MINIMUM	MAXIMUM	STANDARD DEVIATION
Lubrication	3.9	.2	36.7	7.7
Rd wheels-Idler-Rollers	2.1	.1	25.3	4.4
Arms & Hubs	2.1	.1	25.3	4.4
Shk Abs & Bpr Sprg	.6	.1	2.2	.6
Torsion Bars	.8	.1	3.0	.8
Sprockets	1.3	.1	12.0	2.5
Tracks	1.3	.1	7.7	1.6
Trk Ten & Adj Link	.9	.1	4.7	1.1
Access Covers	.4	.1	1.1	.3
Fenders & Stw Boxes	.6	.1	3.0	.7
Air Cleaner	.8	.1	3.2	.7
External Telephone	.3	.1	1.1	.3
Towpintle-Hooks-Lft Eyes	.3	.1	1.0	.2
Lights	.5	.1	2.2	.5
Deck-G Doors-Trv Lock	.4	.1	1.5	.4
Oil Coolers-Shroud-A/C hose	1.1	.1	10.7	1.9
Power Plant	4.4	.1	20.0	5.1
Oil Levels	.6	.1	4.0	.9
Engine	2.2	.1	14.2	2.7
Transmission	1.2	.1	4.0	1.2
U Joints & Final Drive	.9	.1	8.2	1.5
Fuel System	1.0	.1	4.0	1.0
Seats	.3	.1	.6	.2
Elec Wiring & Components	1.6	.1	12.2	2.2
Batteries	1.3	.1	4.0	1.1
Fire Extg System	1.8	.1	2.2	.5
Driver's Esc Hatch	.4	.1	1.1	.3
Driver's Hatch & Persc	.4	.1	2.1	.4
Drain Valves	.5	.1	2.2	.4
Hull Turret Seal	.5	.1	2.0	.5
Hydraulic Brake System	1.0	.1	3.0	.8
Personnel Heater	.5	.1	2.0	.5
Int Lights-Rheostats	.5	.1	2.0	.5
Strtr Switch-Fuel Shutoff	.6	.1	3.9	.9
Instruments	.6	.1	3.0	.7
Steering Controls	.5	.1	2.0	.5
Shifting Controls	.4	.1	1.8	.4
Brake Controls	.7	.1	4.7	.9
Governed Speed & Perf	.5	.1	2.0	.5

TABLE 4-1(Continued)

TASK	MEAN	MINIMUM	MAXIMUM	STANDARD DEVIATION
Wheel Hubs	.8	.1	3.8	1.0
Shock Absorbers	.5	.1	2.0	.5
Leaks	1.8	.1	20.0	4.0
Decals-Stencil-Paint	.5	.1	1.6	.5
Modifications	.9	.1	7.4	1.8
Final Road Test	1.0	.3	2.1	.5
Gun Shield Cover	.3	.1	1.2	.2
Loader's Hatch	.3	.1	1.2	.3
Ammo Racks & Stw Boxes	.5	.1	2.2	.5
Main Accumulator	.5	.1	4.7	.8
Turret Trav & Hyd Sys	.8	.1	3.7	.8
Grenade Launcher	.5	.1	3.7	.8
M36 Periscope	.3	.1	1.2	.2
M32 Periscope	.3	.1	1.2	.3
Bore Evacuator	.8	.1	2.5	.7
Gun Tube	.7	.1	2.2	.6
Breech Mechanism	.6	.1	2.8	.5
Breech Clsg Mechan	.5	.1	2.0	.4
Firing Contact	.3	.1	1.0	.2
Replenisher	.3	.1	1.1	.2
Emergency Blaster	.2	.1	1.1	.2
Hatch Assy	.3	.1	1.2	.3
Cupola Access Doors	.3	.1	1.1	.3
Terminal Board Assy	.4	.1	1.1	.3
Cupola Assy Ring Gear	.3	.1	1.1	.2
Azimuth Lock Assy	.3	.1	1.2	.3
Cradle Assy	.3	.1	1.2	.3
Cupola Attch Screws	.2	.1	.7	.2
Azimuth Gear Box	.3	.1	1.2	.3
Elevation Screw Jack	.2	.1	.6	.2
Electrical Parts	.9	.1	5.8	1.2
M28C Periscope	.3	.1	.7	.2
M31 Periscope	.3	.1	.7	.1
Sighting Syst Super Elev	.5	.1	2.8	.5
M31 Periscope & M115 Mount	.3	.1	.6	.2
Infinity Sight M44c	.3	.1	1.0	.2
M105D Telescope	.3	.1	1.0	.2
M17 Rangefinder	.5	.1	2.0	.4
Ballistic Computer	.5	.1	2.2	.4
M13A1 Elevation Quadrant	.2	.1	1.2	.2
M28A1 Az Indicator	.3	.1	1.2	.2
Sighting System	.9	.1	3.0	.8

TABLE 4-1(Continued)

TASK	MEAN	MINIMUM	MAXIMUM	STANDARD DEVIATION
Preinspection-Hull	1.5	.2	4.3	1.1
Preinspection-Turret	1.2	.2	3.0	.7
Logbook Check	.5	.1	2.0	.4
Optics Purging	2.2	.1	6.0	1.7
Commo Inspect & Rpr	1.3	.3	6.0	1.1
Stall Ck-Idle Test-No Load	.8	.1	2.2	.6
Power Pack Installation	1.4	.2	5.7	1.2
Commo Test	.6	.1	1.9	.4
Fire Control Synchron	1.2	.2	3.5	.9
Bore Scope & Pullover	.7	.1	2.1	.5
Logbook Update	.5	.1	2.1	.4

start servicing simultaneously?

1. One
2. Two
3. Three
4. Four
5. Five
6. Six
7. Seven
8. Over seven-specify_____

Results. See Table 4-2

Although the results indicate a mode of six tanks, the researchers believe these results should have shown a higher occurence of six. The word "simultaneously" may have caused some confusion since a service of six tanks may only "simultaneously" start four of those tanks and later start the other two in a staggered manner. The results of item 14 (a verbal description by the respondent of his system of scheduling tanks) lend credence to the supposition that six tanks should be serviced simultaneously. Based on those points the researchers established the final network model utilizing six tanks serviced simultaneously.

Question eight. Are facilities a constraint in your scheduled maintenance program?

1. A major constraint
2. A moderate constraint
3. A minor constraint
4. No

Explain_____

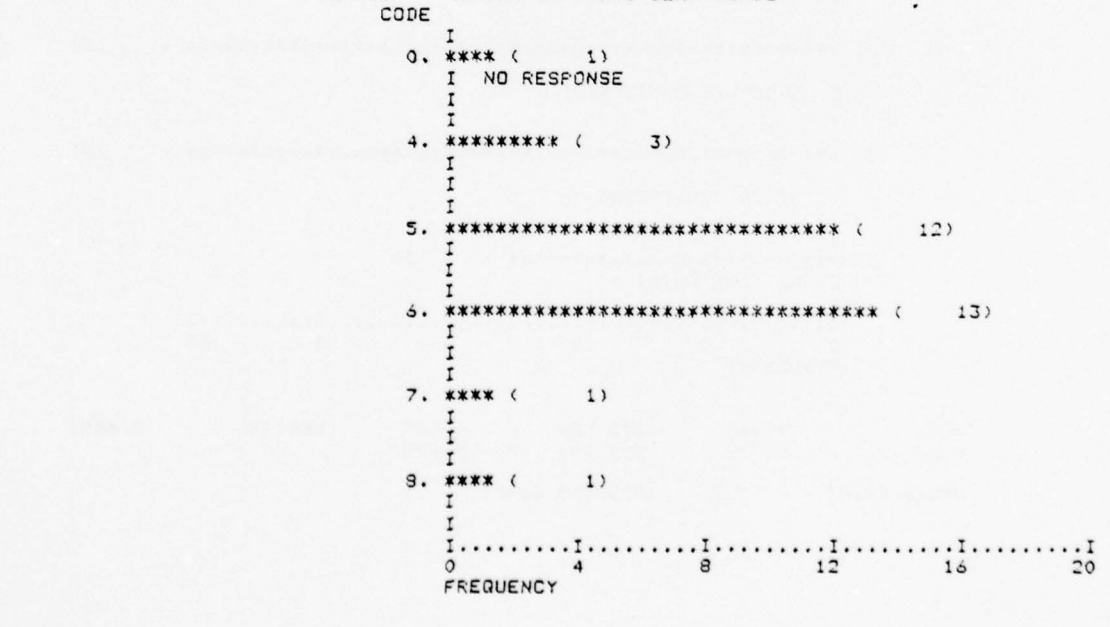
Results. See Table 4-3

Table 4-2

VAR006 NUMBER OF TANKS SERV SIMUL

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NO RESPONSE	0.	1	3.2	3.2	3.2
	4.	3	9.7	9.7	12.9
	5.	12	38.7	38.7	51.6
	6.	13	41.9	41.9	93.5
	7.	1	3.2	3.2	96.8
	8.	1	3.2	3.2	100.0
	TOTAL	31	100.0	100.0	

VAR006 NUMBER OF TANKS SERV SIMUL



MEAN	5.323	STD ERR	0.234	MEDIAN	5.458
MODE	6.000	STD DEV	1.301		
VALID CASES	31	MISSING CASES	0		

Table 4-3

VAR009 FACILITIES CONSTRAINTS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
MAJOR CONSTRAINT	1.	6	19.4	19.4	19.4
MODERATE CONSTRAINT	2.	10	32.3	32.3	51.6
MINOR CONSTRAINT	3.	10	32.3	32.3	83.9
NO CONSTRAINT	4.	5	16.1	16.1	100.0
	TOTAL	31	100.0	100.0	

VAR009 FACILITIES CONSTRAINTS

```
CODE
     I
  1. ****************************** (     6)
     I  MAJOR CONSTRAINT
     I
     I
  2. ********************************************** (    10)
     I  MODERATE CONSTRAINT
     I
     I
  3. ********************************************** (    10)
     I  MINOR CONSTRAINT
     I
     I
  4. ************************ (     5)
     I  NO CONSTRAINT
     I
     I.........I.........I.........I.........I.........I
     0         2         4         6         8        10
     FREQUENCY
```

MEAN	2.452	STD ERR	0.179	MEDIAN	2.450
MODE	2.000	STD DEV	0.995		
VALID CASES	31	MISSING CASES	0		

Question 8 allows users of this study who might be involved in planning levels for future facilities to reflect on how the field users see their facilities. The fact that 83.9 percent of all surveyed considered facilities to be a constraint to some degree seems to indicate that better facility planning should be included as future maintenance facilities are constructed. Additionally, better use of existing facilities might be enhanced by offering some basic facility planning in battalion commander and maintenance officer preparation courses.

Question nine. How do you use scheduled services as repair time?

1. Most of our non-deadline repairs are performed in conjunction with scheduled services.
2. A moderate amount of our non-deadline repairs are performed in conjunction with scheduled services.
3. A small amount of our non-deadline repairs are performed in conjunction with scheduled services.
4. Scheduled services are used for inspection and lubrication only.

Results. See Table 4-4

Since 96.8 percent stated that they did in fact use the service to some degree as repair time, this indicates to the researchers that perhaps adequate day-to-day services are

Table 4-4

VAR010 SCHD SERV AS REPAIR TIME

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
MOST	1.	8	25.8	25.8	25.8
MODERATE	2.	12	38.7	38.7	64.5
SMALL AMOUNT	3.	10	32.3	32.3	96.8
NONE	4.	1	3.2	3.2	100.0
	TOTAL	31	100.0	100.0	

VAR010 SCHD SERV AS REPAIR TIME

```
CODE
        I
   1. ********************  (      8)
      I  MOST
      I
      I
   2. ******************************  (     12)
      I  MODERATE
      I
      I
   3. ************************  (     10)
      I  SMALL AMOUNT
      I
      I
   4. ****  (      1)
      I  NONE
      I
      I.........I.........I.........I.........I.........I
      0         4         8        12        16        20
      FREQUENCY
```

MEAN	2.129	STD ERR	0.152	MEDIAN	2.125
MODE	2.000	STD DEV	0.846		
VALID CASES	31	MISSING CASES	0		

not being maintained as they should be. Even though theoretically most repairs should be completed as they are found, realistically that policy would require much more non-use time than Army readiness standards allow. The alternatives here are to either adjust readiness standards or to adjust the policy on what items can feasibly be left unrepaired until scheduled service time. The latter policy would cause longer in-scheduled-service times and require more emphasis on completing a quality scheduled service.

Question ten. How adequate is the current -20 manual in providing you with information to plan scheduled services?

1. Totally adequate
2. Very adequate
3. Slightly adequate
4. Slightly inadequate
5. Very inadequate
6. Totally inadequate

Results. See Table 4-5

The results of this question left little for analysis or discussion. Since 74.2 percent considered the Training Manual 9-2350-215-20 to be at least very adequate, there seems to be little reason or call for changes. It might be noted here that this perception of the field runs somewhat contrary to current reports of training agencies that state there is a need for more simplified manuals.

Question eleven. Is Class IX lead time a constraint in

Table 4-5

VAR011 ADEQUACY OF 20 MANUAL

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NO RESPONSE	0.	1	3.2	3.2	3.2
TOTALLY ADEQUATE	1.	2	6.5	6.5	9.7
VERY ADEQUATE	2.	20	64.5	64.5	74.2
SLIGHTLY ADEQUATE	3.	4	12.9	12.9	87.1
SLIGHTLY INADEQUATE	4.	3	9.7	9.7	96.8
VERY INADEQUATE	5.	1	3.2	3.2	100.0
	TOTAL	31	100.0	100.0	

VAR011 ADEQUACY OF 20 MANUAL

```
     CODE
          I
       0. **** (      1)
          I  NO RESPONSE
          I
          I
       1. ****** (      2)
          I  TOTALLY ADEQUATE
          I
          I
       2. ********************************************************** (     20)
          I  VERY ADEQUATE
          I
          I
       3. *********** (      4)
          I  SLIGHTLY ADEQUATE
          I
          I
       4. ********** (      3)
          I  SLIGHTLY INADEQUATE
          I
          I
       5. **** (      1)
          I  VERY INADEQUATE
          I
          I.........I.........I.........I.........I.........I
          0         4         8        12        16        20
          FREQUENCY
```

MEAN	2.290	STD ERR	0.175	MEDIAN	2.125
MODE	2.000	STD DEV	0.973		
VALID CASES	31	MISSING CASES	0		

scheduling services?

1. A major constraint
2. A moderate constraint
3. A minor constraint
4. No

Results. See Table 4-6

Question thirteen. How much Class IX lead time do you allow in scheduling of services?

1. One week
2. Two weeks
3. Three weeks
4. Four weeks
5. Five weeks
6. Six weeks

Results. See Table 4-7

Questions 11 and 13 are grouped together since they both concern Class IX (Repair Parts) as it affects scheduled services. The results of question 11 shows that 87.1 percent of the respondents believed that Class IX requirements constrained the abilities of the respondents to perform services. Since the respondents felt constrained by Class IX requirements, it follows that they would order Class IX allowing some lead time for delivery. Question 13 verifies that conclusion since 90.3 percent of the respondents did allow at least one week of Class IX lead time. The researchers believe that this indicated a need for better planning in ordering Class IX for scheduled services as well as more concrete guidance on what to order. Battalion maintenance platoon normally has to depend on the company maintenance sections to order those Class IX

Table 4-6

VAR012 CLASS IX CONSTRAINTS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
MAJOR CONSTRAINT	1.	8	25.8	25.8	25.8
MODERATE CONSTRAINT	2.	14	45.2	45.2	71.0
MINOR CONSTRAINT	3.	5	16.1	16.1	87.1
NO CONSTRAINT	4.	4	12.9	12.9	100.0
	TOTAL	31	100.0	100.0	

VAR012 CLASS IX CONSTRAINTS

```
CODE
       I
    1. ********************** (      8)
       I  MAJOR CONSTRAINT
       I
       I
    2. **************************************** (     14)
       I  MODERATE CONSTRAINT
       I
       I
    3. ***************** (      5)
       I  MINOR CONSTRAINT
       I
       I
    4. ************ (      4)
       I  NO CONSTRAINT
       I
       I.........I.........I.........I.........I.........I
       0         4         8        12        16        20
       FREQUENCY
```

MEAN	2.161	STD ERR	0.174	MEDIAN	2.036
MODE	2.000	STD DEV	0.969		
VALID CASES	31	MISSING CASES	0		

Table 4-7

```
VAR014    CLASS IX LEAD TIME
     CODE
          I
       0. *********  (      3)
          I  NO RESPONSE
          I
          I
       1. ****  (      1)
          I
          I
          I
       2. *********  (      3)
          I
          I
          I
       3. ***********  (      4)
          I
          I
          I
       4. ***********  (      4)
          I
          I
          I
       6. ***************************************  (     15)
          I
          I
          I
      10. ****  (      1)
          I
          I
          I.........I.........I.........I.........I.........I
          0         4         8        12        16        20
          FREQUENCY
```

MEAN	4.355	STD ERR	0.421	MEDIAN	5.533
MODE	6.000	STD DEV	2.346		
VALID CASES	31	MISSING CASES	0		

VAR014 CLASS IX LEAD TIME

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NO RESPONSE	0.	3	9.7	9.7	9.7
	1.	1	3.2	3.2	12.9
	2.	3	9.7	9.7	22.6
	3.	4	12.9	12.9	35.5
	4.	4	12.9	12.9	48.4
	6.	15	48.4	48.4	96.8
	10.	1	3.2	3.2	100.0
	TOTAL	31	100.0	100.0	

items required for services which complicates this process even more. Possibly a better system, as suggested by one respondent, would be to allow the battalion maintenance section to order and store common Class IX parts used for scheduled services.

Analysis of Planning Related Survey Questions

The questions discussed in this section dealt with the problems facing the battalion motor officer in planning and conducting scheduled services. The general format of this section follows that of the first section with the exception of questions which asked for a descriptive, non-specific answer from the respondent. Questions of the latter type were analyzed by consolidating responses and developing subjective evaluations.

Question seven. How many working days do you consider adequate to complete a scheduled service based on the number of tanks you schedule at one time and the personnel dedicated to scheduled services?_____working days per_____tank(s).

This question was asked to ascertain how long services were generally taking units in the field. This allowed the researchers to match the total completion times against the network model that was developed. This in turn gave a realistic evaluation of how well services were being done in compari-

son with the average times gathered by the survey. The end purpose in the collection of this data is to allow a unit to determine how it compares to a standardized range of times from the developed network model. From that point the unit should be able to adjust its qualitative effort to insure a better scheduled service.

To put the figures in more meaningful format, the number of days was divided by the number of tanks serviced in that period. This yielded a figure from 0.67 days per tank to 2.33 days per tank or a weighted average of 1.12 days per tank or 53.76 hours for servicing 6 tanks simultaneously. These figures were used to help establish some conclusions in the section on the network model.

Question twelve. If you conduct an advance inspection prior to starting a scheduled service, how far in advance is it conducted?

1. No advance inspection
2. One week prior
3. Two weeks prior
4. Three weeks prior
5. Four weeks prior
6. Five weeks prior
7. Six weeks prior
8. More than six weeks prior-specify_____

Results. See Table 4-8

The results of question 12 showed that 68 percent of the respondents did not perform an advance inspection. Not

Table 4-8

VAR013 ADVANCE INSPECTION

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NO RESPONSE	0.	1	3.2	3.2	3.2
NO INSPECTION	1.	21	67.7	67.7	71.0
ONE WEEK	2.	7	22.6	22.6	93.5
TWO WEEK	3.	2	6.5	6.5	100.0
	TOTAL	31	100.0	100.0	

VAR013 ADVANCE INSPECTION

```
CODE
     I
  0. ** (      1)
     I  NO RESPONSE
     I
     I
  1. ********************** (     21)
     I  NO INSPECTION
     I
     I
  2. ******** (      7)
     I  ONE WEEK
     I
     I
  3. *** (      2)
     I  TWO WEEK
     I
     I.........I.........I.........I.........I.........I
     0        10        20        30        40        50
     FREQUENCY
```

MEAN	1.323	STD ERR	0.117	MEDIAN	1.190
MODE	1.000	STD DEV	0.653		
VALID CASES	31	MISSING CASES	0		

performing an advance inspection would normally result in not knowing explicitly what Class IX parts are needed for the upcoming scheduled services. Of course certain Class IX parts are used practically for every service. But not performing an advanced inspection for the scheduled services would probably result in problems in acquiring the needed Class IX parts upon commencing the actual service. As questions 11 and 13 indicated, this is indeed what is occuring - Class IX is a constraint to 87.1 percent of the respondents. This indicated to the researchers that the use of an advance inspection prior to the actual start of scheduled service could possibly alleviate some of the Class IX problems that units experience. Additionally, advance inspections serve the function of identifying major problems that might influence the planning aspect of scheduled services.

Question fourteen. Do you use a particular system of scheduling tank services (i.e. one platoon plus a headquarters tank)? If yes, what is the system and why do you use it?

This question was used as a verification and explanation of items 6 and 7. It allowed the respondent to also list his specific system and why he believed that system worked. The responses of this section generally recommended servicing one platoon of tanks (5) plus one tank from headquarters section for a total of six. The reasons stated for this method included:

better management of personnel, better utilization of available time, better management of facilities, and more involvement of platoon supervisors and the crews.

Question 16. What are the grades and MOSs of your scheduled service team, and where do they come from (company or battalion assets)?

MOS	GRADE	FROM

Results. See Table 4-9

The survey showed only 45 percent of those answering utilize a supervisor above the E-5 level. The researchers believed that this might be a possible area of adding emphasis to the scheduled services if a supervisor, E-6 or above, was required.

Some units considered the recovery operators and communications specialists as part of their scheduled service team. Recovery operators and communications specialists used full time on the scheduled service team would probably be underutilized unless they were also used as mechanics. However, not having these members can be frustrating and can cause service delays. The researchers believe that with a minimum planning effort, these members could be used in an on-call basis rather than as full time members.

Track mechanics, as expected, are the most utilized personnel in the scheduled service. The range of three to six

TABLE 4-9

COMPOSITION OF SCHEDULED SERVICE TEAMS

POSITION	GRADE	NUMBER ON TEAM	NUMBER FOR OPTION OUT OF 20 SURVEYS[1]
Supervisor	WO 3 to E6	0	11
		1	9
Recovery Operator	E5 to E3	0	13
		1	3
		2	4
Track Mechanic	E5 to E2	0	0
		1	1
		2	0
		3	4
		4	8
		5	4
		6	3
Turret Mechanic	E6 to E2	0	1
		1	2
		2	6
		3	10
		4	1
Communications Specialist	E5 to E2	0	16
		1	3
		2	1

NOTE 1 - 20 surveys out of the total 31 received had categorizable information on this item. Only six surveys of the total received listed from where the personnel were drawn.

mechanics utilized accounted for 95 percent of those surveyed. The choices reflected by the surveys were tested in the network model established by the researchers.

The number of turret mechanics used varied from zero to four with 50 percent using three. Increasing the number of turret mechanics over two actually had little effect on the total scheduled service time as shown in the results of the network model in Table 4-12.

Question seventeen. Do you shift scheduled service responsibilities between company and battalion level depending on the Q service being performed? If so, how?

The responses to this question indicated 61.3 percent did shift responsibility between battalion and company. The same percent allowed the battalion maintenance section to perform the second and fourth services while the company maintenance section performed the first and third services. The surveys indicated that the reasons behind battalion doing the second and fourth services was because the assets there were more able to perform the two more extensive services. Some respondents also indicated that this arrangement allowed better utilization of company and battalion assets.

Question eighteen. At what point(s) during the Q service, do you perform logbook updates? Who performs this function?

Although this item is actually not required in the

scheduled services, it is a necessary action to insure proper bookkeeping as well as timely actions on Class IX parts and on maintenance requirements. A few of the respondents indicated that entries were made daily, throughout the service; but most indicated that the logbooks were not updated until the end of the service. Most respondents also indicated that the company maintenance clerk performed the actual logbook update for the scheduled services.

Analysis of Service Frequency

Service frequency analysis is based on maintenance officer responses to survey question 19 and the recommended frequency for each individual tasks in the questionnaire. Of the 31 responses to question 19, 25 believed the current requirement is adequate and necessary. Of the remaining six, three believed that a semiannual service would be adequate; one believed that a service every four months would be adequate; and two believed that the current requirement was too much based on training requirements. All six that believed that a quarterly service was too much, mentioned current training requirements as the basis for their reasoning.

The results of the individual task frequencies showed a similar trend as question 19. The results are summarized in Table 4-10. A complete listing of the responses to task frequencies is presented in Table 4-11.

TABLE 4-10

AVERAGE RESPONSES FOR 93 TASKS

FREQUENCY	MEAN	STANDARD DEVIATION	VARIANCE
Quarterly	26.03	2.75	7.6
Semiannually	2.16	1.70	2.9
Annually	.46	.62	.4
Delete	1.74	1.91	3.7
No Response	.78	1.90	3.9

TABLE 4-11

RESPONSES TO INDIVIDUAL TASK FREQUENCY
(31 RESPONSES)

TASK	QUART	SEMI	ANNUAL	DELETE	NO RESPONSE
Lubrication	29	1	1	0	0
Rd Wheels-Idler-Rollers	29	1	1	0	0
Arms & Hubs	29	0	0	2	0
Shk Abs & Bpr Sprg	25	3	0	3	0
Torsion Bars	25	1	0	5	0
Sprockets	25	3	1	2	0
Track	27	2	1	1	0
Trk Tension & Adj Link	25	1	2	3	0
Access Covers	24	3	1	3	0
Fenders & Stw Boxes	22	0	3	6	0
Air Cleaner	29	1	0	1	0
External Telephone	25	4	0	2	0
Tow Pintle-Hooks-Lifting Eyes	25	1	1	4	0
Lights	27	0	1	3	0
Top Deck-Grille Doors-Travel Lock	26	2	1	2	0
Oil Coolers-Shroud Seal & A/C Hoses	25	6	0	0	0
Power Plant	22	7	2	0	0
Oil Levels	26	1	1	3	0
Engine	24	6	0	1	0
Transmission	23	7	0	1	0
U Joints & Final Drive	25	6	0	0	0
Fuel System	28	3	0	0	0
Seats	23	3	0	5	0
Electrical Wiring & Components	23	6	1	1	0
Batteries	29	1	1	0	0
Fire Extg System	28	3	0	0	0
Gas Part Filter System	24	4	1	2	0
Driver's Escape Hatch	26	2	0	3	0
Driver's Hatch & Periscope	25	2	0	4	0
Drain Valves	26	0	1	4	0
Hull Turret Seal	25	2	0	4	0

TABLE 4-11(Continued)

TASK	QUART	SEMI	ANNUAL	DELETE	NO RESPONSE
Hydraulic Brake System	28	2	1	0	0
Personnel Heater	23	4	0	4	0
Interior Lights-Rheostats-Switches	26	3	0	2	0
Strtr Switch-Fuel Shut-off-Purge Pump	26	2	2	1	0
Instruments-Gauges-Warning Light	28	1	1	1	0
Steering Controls	29	2	0	0	0
Shifting Controls	28	2	1	0	0
Brake Controls	26	3	1	1	0
Governed Speed & Performance	28	3	0	0	0
Wheel Hubs	27	1	0	3	0
Shock Absorbers	23	2	1	5	0
Leaks	26	1	0	4	0
Decals-Stencil-Paint	21	3	1	6	0
Modifications	16	31	1	10	1
Final Road Test	30	0	0	1	0
Gun Shield Cover	28	0	1	2	0
Loader's Hatch	27	2	1	1	0
Ammo Racks & Stowage Boxes	28	2	1	0	0
Main Accumulator	30	1	0	0	0
Turret Traversing & Hydraulic System	29	2	0	0	0
Grenade Launcher	18	2	0	5	6
M36 Commander's Periscope	28	2	0	1	0
M32 Gunner's Periscope	28	2	0	1	0
Bore Evacuator	28	2	0	0	1
Gun Tube	29	1	0	0	1
Breech Operating Mech	30	0	0	1	0
Breech Block Closing Mechanism	29	1	0	1	0
Firing Contact	31	0	0	0	0
Replenisher	30	0	0	1	0
Emergency Firing Device	27	2	0	1	0
Hatch Assembly	24	3	0	3	1
Cupola Access Doors	24	3	0	2	2
Terminal Board Assembly	23	1	0	5	2
Cupola Assembly Ring Gear	28	1	0	2	0
Azimuth Lock Assembly	28	1	1	1	0
Cradle Assembly	28	2	1	0	0

TABLE 4-11(Continued)

TASK	QUART	SEMI	ANNUAL	DELETE	NO RESPONSE
Cupola Attaching Screws	25	2	0	4	0
Azimuth Gear Box	28	1	2	0	0
Elevation Screw Jack	29	0	2	0	0
Electrical Parts	28	2	0	0	1
M28C Commander's Periscope	21	2	0	5	3
M31 Gunner's Periscope	23	2	0	3	3
Sighting System Super Elevation Check	27	3	0	0	1
M31 Periscope & M115 Mount	22	2	0	4	3
Infinity Sight M44C	25	3	0	2	1
M105D Telescope	28	2	0	0	1
M17 Range Finder	28	1	1	0	1
Ballistic Computer	30	0	0	0	1
M13A1 Elevation Quadrant	28	1	1	0	1
M28A1 Azimuth Indicator	28	1	1	0	1
Sighting System	27	3	0	0	1
Preinspection Hull	27	0	0	2	2
Preinspection Turret	27	0	0	2	2
Logbook Check	26	1	0	2	2
Purging Fire Control	25	4	1	0	1
Commo Inspection & Repair	26	1	0	2	2
Stall Check-Idle Test-No Load Test	24	4	0	1	2
Power Pack Installation	22	7	0	0	2
Commo Test	23	1	0	3	4
Fire Control Synchronization	26	4	1	0	0
Borescope & Pullover	21	6	2	2	0
Logbook Update & Service Completion	28	1	0	0	2

PERT/Q-GERT ANALYSIS OF TOTAL NETWORK TIME

As previously mentioned, times were established for individual tasks from the questionnaire responses provided by armor battalion maintenance officers. These times provided the individual task times used in the PERT/Q-GERT model. Precedence relationships were established from the network shown in Appendix A, section E. The network shown in Appendix A, was based on the experience of the researchers and provided to the armor battalion maintenance officers via the questionnaire for comments. Comments from the battalion maintenance officers ranged from full approval of model to approval with minor reservations concerning complexity.

After times were compiled and precedence relationships were established, the Q-GERT network was flowcharted and coded (see Appendix D, Section 3). The resources capability and the match node capability of Q-GERT gave the researchers the ability to model the limited manpower resources in the battalion maintenance platoon and to effectively control the precedence relationships with multiple transactions (six tanks) in the system. Once the network was established, it was simply a matter of changing one line of coding to vary the available resources in the model. The two resources used in this model were automotive mechanics and turret mechanics. From the analysis of survey item 16 and from the development of the network model, it was determined that the use of

recovery personnel and communications specialists was not time restrictive in the overall network model.

The quarterly service model was run several times. With each run, the number of automotive mechanics and turret mechanics was varied to determine the sensitivity of the model to changes in mechanics. In all cases, the automotive path was the critical path except for activities conducted by the turret mechanics after road testing. Completion times and resource utilization for varying combinations of turret and automotive mechanics are shown in Table 4-12.

TABLE 4-12

QUARTERLY SERVICE COMPLETION TIMES
BASED ON Q-GERT MODEL
(60 SIMULATIONS)

MECHANIC RESOURCES AVAILABLE	AVERAGE COMPLETION TIME (WORK HOURS)	COMPLETION TIME 95% CONFIDENCE INTERVAL
2-Turret 4-Automotive	145.3	± 4.7
2-Turret 5-Automotive	129.7	± 3.8
3-Turret 5-Automotive	129.7	± 4.0
2-Turret 6-Automotive	92.0	± 3.2
2-Turret 7-Automotive	92.3	± 3.2
3-Turret 6-Automotive	90.8	± 3.4
3-Turret 7-Automotive	92.5	± 3.2

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

The purpose of this chapter was threefold. The first purpose was to draw conclusions from the results of the survey and model analysis based on the thesis research objectives and research questions. Key to success in this case was to analyze and explain that information in terms that supported the purpose of the entire thesis - to improve scheduled services for the M60A1 tank. Although many points could be drawn from the analysis, there was little to be gained unless it supported the original end purpose. Given those propositions, the second purpose of this chapter was to make recommendations for implementation based directly on the analysis done by the researchers of the survey and the recommended model. This purpose had to fulfill the stringent requirements of being subjectively appraised to be worthwhile to implement. These recommendations proved to be only ones that could be supported with strong evidence of the need for their implementation. Many others could be recommended but the desire to do so was tempered with the realization of value and scientifically based truth. Finally, the third

purpose was to make recommendations for further study of those items that the researchers touched upon in their analysis but could not examine fully within the scope of the stated objectives or within the limits of time and resources. However, those recommendations for further study were made as a result of in depth analysis of the stated objectives. Again many ideas could have been included within this section, but again the researchers tried to limit the recommendations to those that were able to enhance United States Army efficiency and effectiveness as related to vehicular maintenance and scheduled service practices.

RESEARCH SUMMARY

The first research objective of identifying organizational variables that affect M60A1 scheduled service times proved to be achievable. The researchers were able to determine several of the variables that affected the length of time required to perform various items of the scheduled service, but the total service time changed by only 10 to 12 hours overall regardless of improvements on specific variables. Therefore, to identify those variables as they affected time proved to be little value in changing the outcome of the overall model. With that discovery, the researchers believed the essential items that required their attention were the planning and preparation of the unit prior to the service and the

quality of the service once initiated.

The second research objective was to determine optimal times for accomplishing each of the tasks included in the M60A1 scheduled service. This objective was highly congruent with the researchers' efforts to focus on items affecting planning. This objective was achieved by the receipt and compilation of the results obtained from sections A, B, C, and D of the survey contained in Appendix A. These results are summarized in Table 4-1. A simple average of times could have been asked of the survey respondent but would have produced a model just as inflexible as the current five day scheduled service plan offered by the United States Army Armor School. The researchers believed that by designing the survey to reflect the mean, minimum, and maximum times for each of the required items of a scheduled service, and then utilizing those in the PERT/Q-GERT model, they were able to enhance the accuracy and applicability of the resulting times. Providing a minimum and maximum time for each task also allows for the variation encountered in M60A1s, the different training, and experience levels of assigned personnel. These same points help answer the first research question concerning the accuracy of the individual times. Actual verification of the computed times for each item of the scheduled service can only be accomplished by further research which would include a similar questioning of required service

times. The accuracy in this research must be subjectively evaluated by the reader for an impartial view of the researchers' methods of accumulation and compilation. Whatever the outcome of any subjective evaluation, the reseachers believe that the individual times provide realistic and usable goals by which the battalion maintenance officer can monitor the battalion scheduled service program and detect strength and weaknesses.

The third research objective and second research question dealt with constructing a viable network model that could be used in planning and performing M60A1 scheduled services. Again, the results presented in Table 4-12 require the reader's subjective evaluation. The researchers believe that the model is much more realistic and viable than the current inflexible five day model taught by the Armor School. Providing model output in working hours allows the reader to interpret the results in terms of current day lengths applicable to his unit. The researchers recognized that the time to complete a service in accordance with the model may be difficult to achieve in view of current training requirements; however, the improvement of readiness rates from a viable scheduled service program should improve existing training and offset any loss of training time to scheduled maintenance. The physical representation of the model presented in Appendix E allows maintenance supervisors to quickly monitor sched-

uled services and concentrate on problem areas.

CONCLUSIONS

First, there is a need in armor battalions to provide the maintenance officer with times to perform individual tasks and overall scheduled service. The researchers believe that the times provided in this thesis will be able to meet the need for times by armor battalions. Second, there is a need for the Armor School to adopt a more flexible model which would allow for better planning in armor battalions. The scheduled service model provided in this thesis will allow the adaptive planning needed by an armor battalion. Third, the researchers have concluded the current scheduled service guidance needs to address facility layouts, preliminary inspections, Class IX, scheduled service crew composition, and those additional tasks covered in section D of the questionnaire. Fourth, there is a need for a planning appendix in the M60A1 organizational maintenance manual to assist the battalion maintenance officer in planning scheduled services and integrating them into the battalion training schedule. The researchers believe that the information in this thesis provides an excellent basis for such a planning appendix. Finally, the difference between the current time standards being applied in various battalions (see question 7) and the model results based on the times provided by the maintenance

officers (see Table 4-12) led the researchers to suspect that current services are not being performed to achieve the highest possible quality, but rather to meet training constraints.

RECOMMENDATIONS

The researchers believe that the recommendations resulting from this study should be divided into those that could be implemented directly from their research and those that required further study or analysis.

Recommendations for Implementation

1. That the field estimated times with a standard deviation and a minimum and a maximum developed for each of the 93 individual tasks (Table 4-1), the PERT planning chart (Appendix E), and the optimal scheduled service team options (Table 4-12), each be included in a planning appendix added in Training Manual 9-2350-215-20 for the M60A1 Tank.
2. That the Armor School, Fort Knox, Kentucky adopt the items in one above into their teaching curriculum.
3. That the results of this research be made available to armor battalion motor officers worldwide to allow them to compare and adjust their own programs when the information therein could induce enhancements.
4. That doctrinal changes be evaluated by the Armor School

and M60 Tanks Project Management Office concerning the field responses to survey items 6, 9, 11, 13, 16, and 17.

5. That based on the survey responses as shown in Table 4-11, items D01 through D11 be incorporated into the scheduled service as required items (see Appendix A, Section D).

Recommendations for Further Study

1. That a follow-up study be done to validate the time estimates garnered by this research.

2. That this type of study be conducted for other vehicles that will remain in the Army inventory for extended periods. (A prime candidate at this point would be the new XM1 main battle tank as it is tested by field units.)

3. That cost effectiveness studies be initiated on high scheduled service cost items, such as armored vehicles, where the most cost effective time between scheduled services could be established as opposed to simply assigning a quarterly service because that happens to be the standard used in the past.

4. That a study be conducted on the effectiveness of training and use of tank crew members as mechanics oriented primarily toward assisting in scheduled services.

APPENDIX A

SCHEDULED SERVICES QUESTIONNAIRE

DEPARTMENT OF THE ARMY
PROJECT MANAGER, M60 TANKS
WARREN, MICHIGAN 48090

14 FEB 1979

DRCPM-M60

SUBJECT: Solicitation of your Ideas for Improving the Preventive Maintenance Checks and Services

1. Captains Frick and Sasser, students at the Air Force Institute of Technology, School of Systems and Logistics, are conducting a survey concerning PMCS, to gather information for a thesis. They will provide to us a final copy of their report.

2. You are well aware of the importance of tank maintenance in your unit today. Therefore, it would be to the Army's benefit for you to take a few minutes of your time to express your ideas about how the PMCS program can be improved. The survey provides to you the opportunity to make your feelings known. It will hopefully lead to easier, more effective PMCS.

3. I thank you in advance for your time and your ideas.

RICHARD H. SAWYER
Colonel, OrdC
Project Manager, M60 Tanks

1 Incl
as

Survey No. DAPC-MSP-S-79-10

TO: Battalion Maintenance Officers

1. The purpose of this questionnaire is to obtain information on PMCS (Quarterly service) procedures and time requirements of the M60A1. The procedures and times listed in TM 9-2350-215-20 provide only minimal information on time requirements and subsystem interrelationships of armament, fire control and automotive.

2. The information obtained will be used to help develop a more accurate and useful network scheduling model. Hopefully, this model will be simple and informative. It is intended that an accurate and realistic model will assist the tank battalion in developing an efficient scheduled maintenance program.

3. Information obtained through this questionnaire will be treated in confidence. No attempt will be made to identify individual units or respondents. We encourage you to include comments on areas that affect or improve scheduled services which you feel have not been covered in sufficient detail. Please use opinions of any persons available to your unit and include dissenting opinions if any.

4. The model should be available approximately 1 October 1979 through Defense Documentation Center or through the M60 Project Manager's Office. If you would like to receive further information, please enclose a return address with the questionnaire and we will provide you information necessary to obtain a copy of the final report.

5. Due to the relatively small number of armor battalions and the need to conduct a statistically sound analysis, it is critical that all questionnaires be filled out and returned. To allow for adequate analysis and followup research, we ask that you return the questionnaire not later than 15 April 1979. If training requirements should prevent you from meeting this response date, please complete and return the questionnaire at your convenience.

6. Thank you for the time you spend in filling out this questionnaire. If you have further questions, feel free to contact us at the Air Force Institute of Technology, School of Systems and Logistics, Wright-Patterson Air Force Base, AUTOVON 785-6513/6569. If we are not available when you call, leave your name and AUTOVON number and we will contact you.

LYNN A. FRICK
CPT ARMOR
USA

ROLAND B. [illegible]
CPT ORDNANCE
USA

BACKGROUND INFORMATION (Circle appropriate choice)

1. Major Command
   1.FORSCOM
   2.USAREUR
   3.USARPAC
   4.Other

2. How much maintenance experience have you had in an armor unit at any level?
   1.0-6 Months
   2.6-12 Months
   3.12-18 Months
   4.18-24 Months
   5.24-36 Months
   6.Over 36 Months

3. What is the relative experience level of the maintenance personnel in your unit?
   1.More experienced than most I have worked with.
   2.Slightly more experienced than most I have worked with.
   3.About the same as others I have worked with.
   4.Slightly less experienced than most I have worked with.
   5.Less experienced than most I have worked with.

4. What is the relative experience level of tank crews in your unit?
   1.More experienced than most I have worked with.
   2.Slightly more experienced than most I have worked with.
   3.About the same as others I have worked with.
   4.Slightly less experienced than most I have worked with.
   5.Less experienced than most I have worked with.

5. What is the average age of the tanks in your unit(Use block 11, DA 2408-9)?
   1.0-2 Years
   2.2-4 Years
   3.4-6 Years
   4.6-8 Years
   5.8-10 Years
   6.Over 10 Years

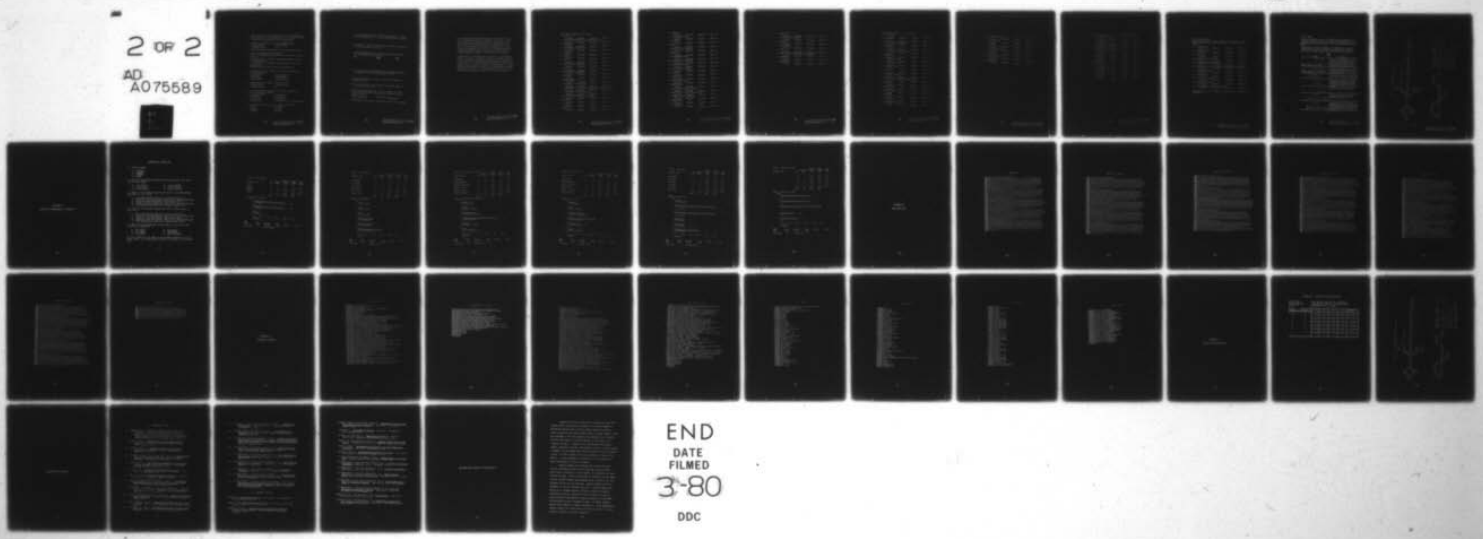
6. How many tanks does your maintenance facility start servicing simultaneously?
   1.One
   2.Two
   3.Three
   4.Four
   5.Five
   6.Six
   7.Seven
   8.Over seven-specify_____

(1)

AD-A075 589 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/G 19/3
IMPROVING THE PREVENTIVE MAINTENANCE CHECKS AND SERVICES PROGRA--ETC(U)
SEP 79 L A FRICK , R E SASSER

UNCLASSIFIED AFIT-LSSR-15-79B NL

2 OF 2
AD A075589



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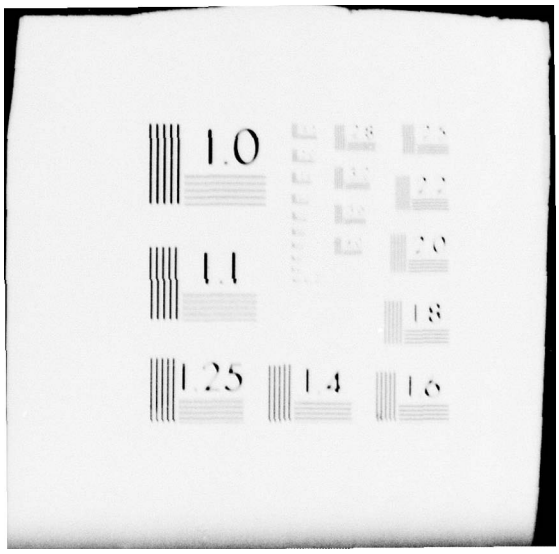

1.0
1.1
1.25
1.4
1.6
2.0
1.8

7. How many working days do you consider adequate to complete a scheduled service based on the number of tanks you schedule at one time and the personnel dedicated to scheduled services?_____working days per_____tank(s).

8. Are facilities a constraint in your scheduled maintenance program?

1.A major constraint
2.A moderate constraint
3.A minor constraint
4.No

Explain_____

9. How do you use scheduled services as repair time?

1.Most of our non-deadline repairs are performed in conjunction with scheduled services.
2.A moderate amount of our non-deadline repairs are performed in conjunction with scheduled services.
3.A small amount of our non-deadline repairs are performed in conjunction with scheduled services.
4.Scheduled services are used for inspection and lubrication only.

10. How adequate is the current -20 manual in providing you with information to plan scheduled services?

1.Totally adequate
2.Very adequate
3.Slightly adequate
4.Slightly inadequate
5.Very inadequate
6.Totally inadequate

11. Is class IX lead time a constraint in scheduling services?

1.A major constraint
2.A moderate constraint
3.A minor constraint
4.No

12. If you conduct an advance inspection prior to starting a scheduled service, how far in advance is it conducted?

1.No advance inspection
2.One week prior
3.Two weeks prior
4.Three weeks prior
5.Four weeks prior
6.Five weeks prior
7.Six weeks prior
8.More than six weeks prior-specify_____

13. How much class IX lead time do you allow in scheduling of services?

1.One week
2.Two weeks
3.Three weeks
4.Four weeks
5.Five weeks
6.Six weeks

(2)

14. Do you use a particular system of scheduling tank services(i.e. one platoon plus a headquarters tank)? If yes, what is the system and why do you use it?

15. On a scale of 1-5, what is the current condition of your M60A1 tanks?(one being like new and five being in poor condition)

1 2 3 4 5

16. What are the grades and MOSs of your scheduled service team, and where do they come from(company or battalion assets)?

MOS	GRADE	FROM

17. Do you shift scheduled service responsibilities between company and battalion level depending on the Q service being performed? If so, how?

18. At what point(s) during the Q service, do you perform logbook updates? Who performs this function?

19. What is your opinion on the current requirement for a quarterly service? Is it too much or not enough? Why?

20. If your unit has other than the M60A1 tank or has a mixture of tank models, please include that information below, along with the number of M60A1 tanks currently in your unit.

Model(s)_____ Number of M60A1 Tanks_____

21. Please discuss any items related to Q services which you feel should be addressed?

For the quarterly preventive maintenance checks and services, please list total times in mannours that are required for all aspects of that activity. For each activity list in manhours, the longest time(LOT), the least time(LET), and the normal time(NOT), it would take provided there were no unusual repairs. Times should be for individual tanks. Use one-tenth hour increments for any activity that does not consume exactly one hour periods. For the frequency column, circle the appropriate frequency interval that the check should be accomplished at(Q-quarterly, S-semiannually, A-annually, or D-delete from service altogether).

In answering each of the activities, refer to TM 9-2350-215-20 for a complete description of the activity. Additionally, consider that the personnel performing the service have adequate tools and lubricants needed and that the appropriate manuals are on hand/ on site, and that adequate time(considering your overall unit requirements) exist for the service to be completed to your satisfaction. As a common reference, use estimates that are applicable to your current personnel, maintenance facility, and unit if possible. If you perform additional checks as a part of your quarterly service program, please include these items and the time estimates.

SECTION A-PMCS CHECKLIST TM 9-2350-215-20(HULL)

1. Lubrication

LOT____MH LET____MH NOT____MH FREQ Q S A D

2. Wheels-Road, Compensating Idler, and Track Support Rollers

LOT____MH LET____MH NOT____MH FREQ Q S A D

3. Arms and Hubs

LOT____MH LET____MH NOT____MH FREQ Q S A D

4. Shock Absorber and Bumper Springs

LOT____MH LET____MH NOT____MH FREQ Q S A D

5. Torsion Bars

LOT____MH LET____MH NOT____MH FREQ Q S A D

6. Sprockets

LOT____MH LET____MH NOT____MH FREQ Q S A D

7. Tracks

LOT____MH LET____MH NOT____MH FREQ Q S A D

8. Track Tension and Adjusting Link

LOT____MH LET____MH NOT____MH FREQ Q S A D

9. Access Covers

LOT____MH LET____MH NOT____MH FREQ Q S A D

10. Fenders and Fender Stowage Boxes

LOT____MH LET____MH NOT____MH FREQ Q S A D

11. Air Cleaner

LOT____MH LET____MH NOT____MH FREQ Q S A D

12. External Telephone

LOT____MH LET____MH NOT____MH FREQ Q S A D

13. Tow Pintle, Tow Hooks, Lifting Eyes

LOT____MH LET____MH NOT____MH FREQ Q S A D

14. Lights-Headlights, Tail and Stoplight, Infrared Lights, and Blackout Lights

LOT____MH LET____MH NOT____MH FREQ Q S A D

15. Top Deck, Grille Doors and Gun Travel Lock

LOT____MH LET____MH NOT____MH FREQ Q S A D

16. Oil Coolers, Shroud Seal and Air Cleaner Hoses

LOT____MH LET____MH NOT____MH FREQ Q S A D

16A. Power Plant

LOT____MH LET____MH NOT____MH FREQ Q S A D

17. Oil Levels

LOT____MH LET____MH NOT____MH FREQ Q S A D

18. Engine

LOT____MH LET____MH NOT____MH FREQ Q S A D

19. Transmission

LOT____MH LET____MH NOT____MH FREQ Q S A D

20. U Joints and Final Drive

LOT____MH LET____MH NOT____MH FREQ Q S A D

21. Fuel System

LOT____MH LET____MH NOT____MH FREQ Q S A D

22. Seats

LOT____MH LET____MH NOT____MH FREQ Q S A D

23. Electrical Wiring and Components

LOT____MH LET____MH NOT____MH FREQ Q S A D

24. Batteries

LOT____MH LET____MH NOT____MH FREQ Q S A D

25. Fire Extinguisher System

LOT____MH LET____MH NOT____MH FREQ Q S A D

25A-E. Gas Particulate Filter System

LOT____MH LET____MH NOT____MH FREQ Q S A D

26. Driver's Escape Hatch Cover

LOT____MH LET____MH NOT____MH FREQ Q S A D

27. Driver's Hatch and Periscopes

LOT____MH LET____MH NOT____MH FREQ Q S A D

28. Drain Valves

LOT____MH LET____MH NOT____MH FREQ Q S A D

29. Hull-Turret Seal

LOT____MH LET____MH NOT____MH FREQ Q S A D

30. Hydraulic Brake System

LOT____MH LET____MH NOT____MH FREQ Q S A D

31. Personnel Heater

LOT____MH LET____MH NOT____MH FREQ Q S A D

32. Interior Lights, Rheostats and Switches

LOT____MH LET____MH NOT____MH FREQ Q S A D

33. Starter Switch, Fuel Shutoff, and Purge Pump

LOT____MH LET____MH NOT____MH FREQ Q S A D

34. Instruments, Gages and Warning Light

LOT____MH LET____MH NOT____MH FREQ Q S A D

35. Steering Controls

LOT____MH LET____MH NOT____MH FREQ Q S A D

36. Shifting Controls

LOT____MH LET____MH NOT____MH FREQ Q S A D

37. Brake Controls

LOT____MH LET____MH NOT____MH FREQ Q S A D

38. Governed Speed and Performance

LOT____MH LET____MH NOT____MH FREQ Q S A D

39. Wheel Hubs

LOT____MH LET____MH NOT____MH FREQ Q S A D

39A. Shock Absorbers

LOT____MH LET____MH NOT____MH FREQ Q S A D

40. Leaks

LOT____MH LET____MH NOT____MH FREQ Q S A D

41. Decals, Instruction Plates, Stencil Markings and Paint

LOT____MH LET____MH NOT____MH FREQ Q S A D

42. Modifications

LOT____MH LET____MH NOT____MH FREQ Q S A D

43. Final Road Test

LOT____MH LET____MH NOT____MH FREQ Q S A D

SECTION B-PMCS CHECKLIST TM 9-2350-215-20(TURRET)

44. Gun Shield Cover

LOT____MH LET____MH NOT____MH FREQ Q S A D

45. Loader's Hatch

LOT____MH LET____MH NOT____MH FREQ Q S A D

46. Ammunition Racks and Stowage Boxes

LOT____MH LET____MH NOT____MH FREQ Q S A D

47. Main Accumulator

LOT____MH LET____MH NOT____MH FREQ Q S A D

48. Turret Traversing and Hydraulic System

LOT____MH LET____MH NOT____MH FREQ Q S A D

49. Grenade Lauchar

LOT____MH LET____MH NOT____MH FREQ Q S A D

50. M36 Commander's Periscope

LOT____MH LET____MH NOT____MH FREQ Q S A D

51. M32 Gunner's Periscope

LOT____MH LET____MH NOT____MH FREQ Q S A D

52. Bore Evacuator Chamber

LOT____MH LET____MH NOT____MH FREQ Q S A D

53. Gun Tube

LOT____MH LET____MH NOT____MH FREQ Q S A D

54. Breech Operating Mechanism

LOT____MH LET____MH NOT____MH FREQ Q S A D

55. Breechblock Closing Mechanism and Operating Handle

LOT____MH LET____MH NOT____MH FREQ Q S A D

56. Firing Contact

LOT____MH LET____MH NOT____MH FREQ Q S A D

57. Replenisher Assembly

LOT____MH LET____MH NOT____MH FREQ Q S A D

58. Emergency Firing Device

LOT____MH LET____MH NOT____MH FREQ Q S A D

59. Hatch Assembly

LOT____MH LET____MH NOT____MH FREQ Q S A D

60. Cupola Access Doors

LOT____MH LET____MH NOT____MH FREQ Q S A D

61. Terminal Board Assembly

LOT____MH LET____MH NOT____MH FREQ Q S A D

52. Cupola Assembly Ring Gear

LOT____MM LST____MM NOT____MM FREQ 1 2 3 A D

53. Azimuth Lock Assembly

LOT____MM LST____MM NOT____MM FREQ 1 2 3 A D

54. Cradle Assembly

LOT____MM LST____MM NOT____MM FREQ 1 2 3 A D

55. Cupola Attaching Screws

LOT____MM LST____MM NOT____MM FREQ 1 2 3 A D

56. Azimuth Gear Box

LOT____MM LST____MM NOT____MM FREQ 1 2 3 A D

57. Elevation Screw Jack

LOT____MM LST____MM NOT____MM FREQ 1 2 3 A D

58. Electrical Parts

LOT____MM LST____MM NOT____MM FREQ 1 2 3 A D

(3-21)

SECTION 3-FMCS CHECKLIST TM 9-2350-215-20 (CONVENTIONAL FIRE CONTROL)

1. M36C Commander's Periscope

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

2. M31 Gunner's Periscope

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

3. Sighting System Superelevation Check

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

4. Periscope M31 and Periscope Mount M115

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

5. Infinity Sight M14C

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

6. Telescope M105D

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

7. Range Finder M17

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

8. Ballistic Computer

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

10. Elevation Quadrant M1[illegible]

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

11. Azimuth Indicator M20A1

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

12. Sighting System

LOT____MM LST____MM NOT____MM FREQ 1 3 A D

(3-11)

SECTION D-ADDITIONAL TASKS

The following are additional items that can be performed in conjunction with the quarterly service, but are not formally addressed within the quarterly service checks.

201. Preinspection-Hull
LOT____MH LST____MH NOT____MH FREQ Q S A D

202. Preinspection-Turret
LOT____MH LST____MH NOT____MH FREQ Q S A D

203. Logbook check
LOT____MH LST____MH NOT____MH FREQ Q S A D

204. Purging all fire control/optics
LOT____MH LST____MH NOT____MH FREQ Q S A D

205. Communications inspection and repair
LOT____MH LST____MH NOT____MH FREQ Q S A D

206. Stall check, idle test, no load governed test(use brake applicator tools)
LOT____MH LST____MH NOT____MH FREQ Q S A D

207. Power pack installation
LOT____MH LST____MH NOT____MH FREQ Q S A D

208. Communications test
LOT____MH LST____MH NOT____MH FREQ Q S A D

209. Fire control synchronization
LOT____MH LST____MH NOT____MH FREQ Q S A D

210. Bore scope and pullover
LOT____MH LST____MH NOT____MH FREQ Q S A D

211. Logbook update and completion of the service.
LOT____MH LST____MH NOT____MH FREQ Q S A D

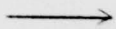
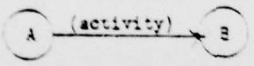
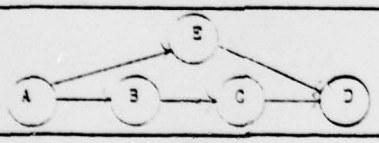
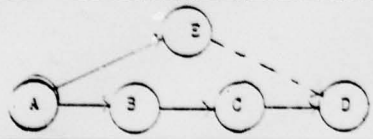
Please use this section for any comments you may have so far and for comments on the final section.

SECTION E-NETWORK

The network on page D-3 is one that we have constructed from our experience with the MOCAI. The numbers correspond to the quarterly service checks as listed in the questionnaire. The network is a graphic portrayal of the subsystems and the precedence relationships such as #17-checking oil levels should precede #18-starting the engine.

Please review the network and make comments on it as appropriate. You may wish to change the numbers to reflect your perception of the subsystem and precedence relationships. In certain cases, we have combined quarterly service checks which we feel can be efficiently managed as a group rather than individual activities.

LEGEND

GRAPHIC	EXPLANATION
 Nodes *NOTE-The letters in the node are only to assist in visualizing the order.	An event which marks a specific accomplishment at a recognizable point in time i.e. a milestone or inspection point. Events have no appreciable time span, they mark the start of one activity and the completion of another activity
 Arrows *NOTE-The length of the arrow does not reflect a scaled time for the activity.	Activities that require time i.e. individual quarterly service checks. Activities must be completed by the node(event) at which they end.
	Simple activity that shows the start(node A), the activity, and the completion(node B).
	Several activities leading to one event. All must be completed before the event associated with the node can be realized or the activity leading from the node can start.
	Several activities starting together.
	Two activities(A-E and E-D) that take place in the same time period as activities A-B, B-C, and C-D.
	One activity(A-E) that takes place in the same time period as A-B, B-C, and C-D. The dotted line shows that A-E must be accomplished before event D can be realized. No activity or time span is associated with the dotted line.

(E-1)

APPENDIX B

PROFILE OF DEMOGRAPHIC INFORMATION

DEMOGRAPHIC QUESTIONS

1. Major Command

   1. FORSCOM
   2. USAREUR
   3. USARPAC
   4. Other

2. How much maintenance experience have you had in an Armor unit at any level?

   1. 0-6 months
   2. 6-12 months
   3. 12-18 months
   4. 18-24 months
   5. 24-36 months
   6. over 36 months

3. What is the relative experience level of the maintenance personnel in your unit?

   1. More experienced than most I have worked with.
   2. Slightly more experienced than most I have worked with.
   3. About the same as others I have worked with.
   4. Slightly less experienced than most I have worked with.
   5. Less experienced than most I have worked with.

4. What is the relative experience level of tank crews in your unit?

   1. More experienced than most I have worked with.
   2. Slightly more experienced than most I have worked with.
   3. About the same as others I have worked with.
   4. Slightly less experienced than most I have worked with.
   5. Less experienced than most I have worked with.

5. What is the average age of the tanks in your unit (Use block 11, DA 2408-9)?

   1. 0-2 years
   2. 2-4 years
   3. 4-6 years
   4. 6-8 years
   5. 8-10 years
   6. Over 10 years

15. On a scale of 1-5, what is the current condition of your M60A1 tanks? (one being like new and five being in poor condition)

   1 2 3 4 5

VAR001 MAJOR COMMAND

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
FORSCOM	1.	15	48.4	48.4	48.4
USAREUR	2.	15	48.4	48.4	96.8
USARPAC	3.	1	3.2	3.2	100.0
	TOTAL	31	100.0	100.0	

VAR001 MAJOR COMMAND

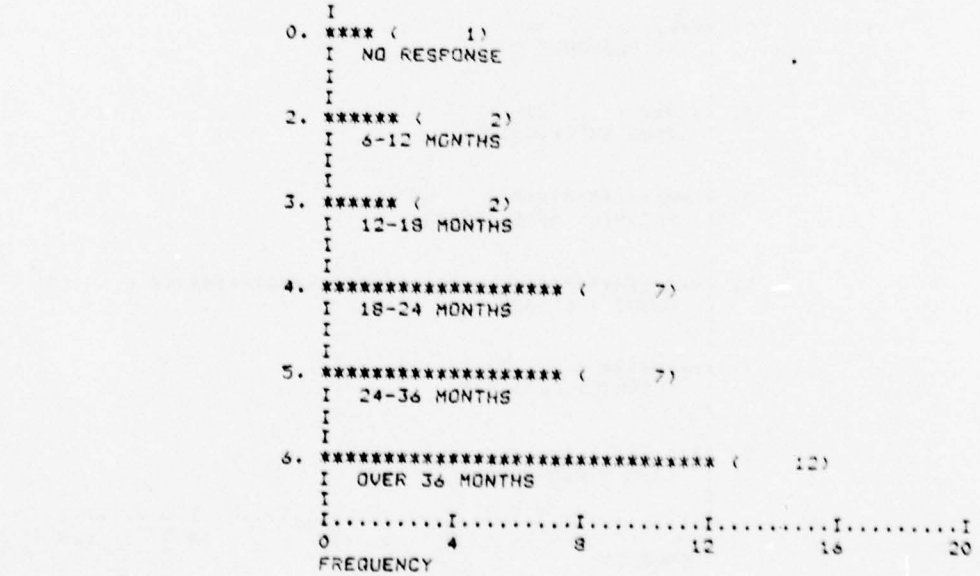
```
CODE
     I
  1. I**************************************** (    15)
     I  FORSCOM
     I
     I
  2. I**************************************** (    15)
     I  USAREUR
     I
     I
  3. I****  (     1)
     I  USARPAC
     I
     I.........I.........I.........I.........I.........I
     0         4         8         12        16        20
     FREQUENCY
```

MEAN	1.548	STD ERR	0.102	MEDIAN	1.533
MODE	1.000	STD DEV	0.568		
VALID CASES	31	MISSING CASES	0		

VAR002 BMO EXPERIENCE

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NO RESPONSE	0.	1	3.2	3.2	3.2
6-12 MONTHS	2.	2	6.5	6.5	9.7
12-18 MONTHS	3.	2	6.5	6.5	16.1
18-24 MONTHS	4.	7	22.6	22.6	38.7
24-36 MONTHS	5.	7	22.6	22.6	61.3
OVER 36 MONTHS	6.	12	38.7	38.7	100.0
	TOTAL	31	100.0	100.0	

VAR002 BMO EXPERIENCE



MEAN	4.677	STD ERR	0.268	MEDIAN	5.000
MODE	6.000	STD DEV	1.492		
VALID CASES	31	MISSING CASES	0		

VAR003 MAINT PERSONNEL EXPERIENCE

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NO RESPONSE	0.	2	6.5	6.5	6.5
MORE EXPERIENCED	1.	2	6.5	6.5	12.9
SLIGHTLY MORE EXPERI	2.	6	19.4	19.4	32.3
ABOUT THE SAME	3.	17	54.8	54.8	87.1
SLIGHTLY LESS EXP.	4.	3	9.7	9.7	96.8
LESS EXPERIENCED	5.	1	3.2	3.2	100.0
	TOTAL	31	100.0	100.0	

```
VAR003    MAINT PERSONNEL EXPERIENCE
     CODE
          I
       0. ****** (     2)
          I  NO RESPONSE
          I
          I
       1. ****** (     2)
          I  MORE EXPERIENCED
          I
          I
       2. ****************** (     6)
          I  SLIGHTLY MORE EXPERI
          I
          I
       3. ***************************************************** (    17)
          I  ABOUT THE SAME
          I
          I
       4. ********* (     3)
          I  SLIGHTLY LESS EXP.
          I
          I
       5. **** (     1)
          I  LESS EXPERIENCED
          I
          I.........I.........I.........I.........I.........I
          0         4         8        12        16        20
          FREQUENCY
```

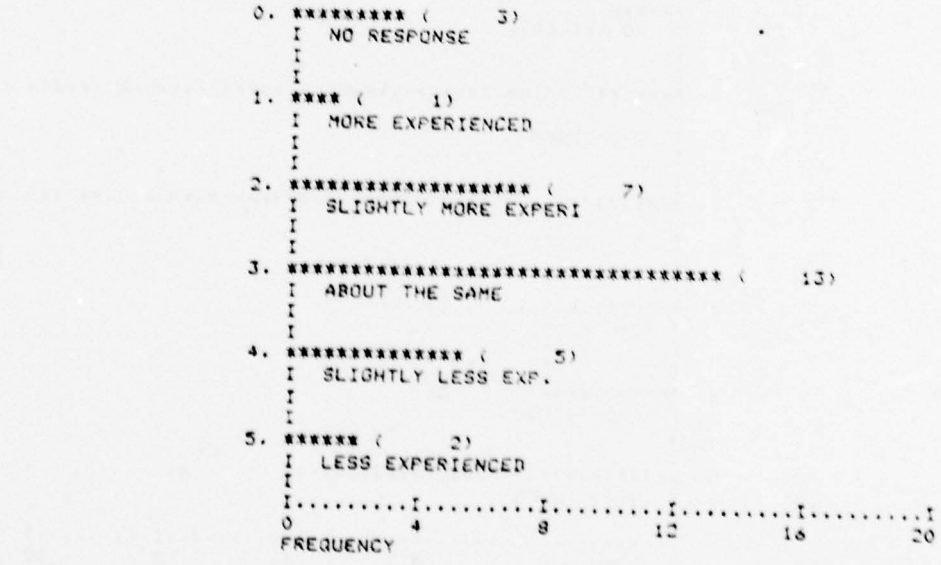
MEAN	2.645	STD ERR	0.194	MEDIAN	2.824
MODE	3.000	STD DEV	1.082		

VALID CASES 31 MISSING CASES 0

VAR004 CREW EXPERIENCE

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NO RESPONSE	0.	3	9.7	9.7	9.7
MORE EXPERIENCED	1.	1	3.2	3.2	12.9
SLIGHTLY MORE EXPERI	2.	7	22.6	22.6	35.5
ABOUT THE SAME	3.	13	41.9	41.9	77.4
SLIGHTLY LESS EXP.	4.	5	16.1	16.1	93.5
LESS EXPERIENCED	5.	2	6.5	6.5	100.0
	TOTAL	31	100.0	100.0	

VAR004 CREW EXPERIENCE
CODE

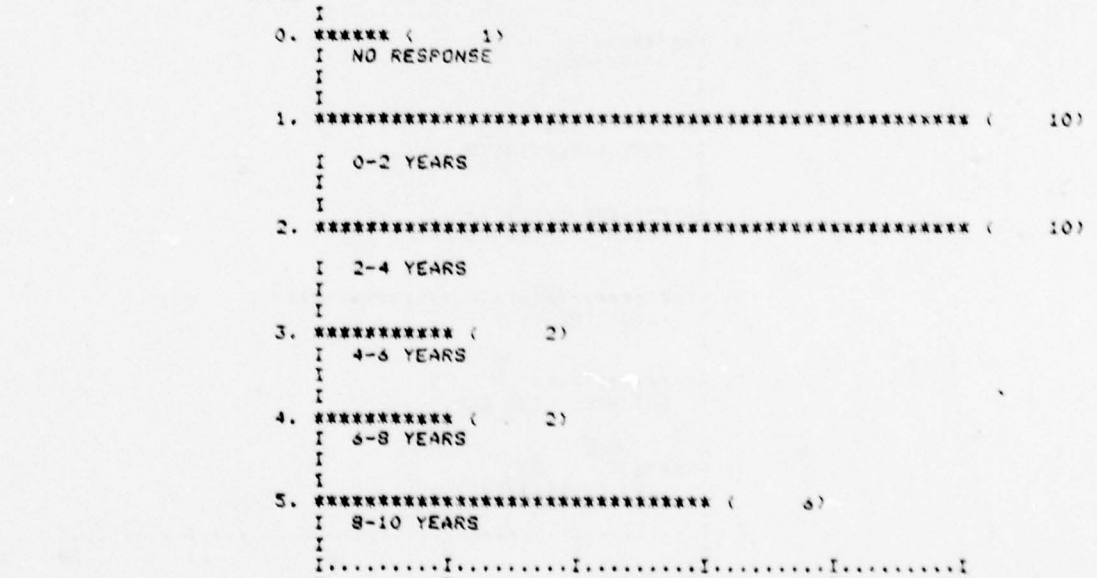


MEAN	2.710	STD ERR	0.228	MEDIAN	2.846
MODE	3.000	STD DEV	1.270		
VALID CASES	31	MISSING CASES	0		

VAR005 AVG TANK AGE

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
NO RESPONSE	0.	1	3.2	3.2	3.2
0-2 YEARS	1.	10	32.3	32.3	35.5
2-4 YEARS	2.	10	32.3	32.3	67.7
4-6 YEARS	3.	2	6.5	6.5	74.2
6-8 YEARS	4.	2	6.5	6.5	80.6
8-10 YEARS	5.	6	19.4	19.4	100.0
	TOTAL	31	100.0	100.0	

VAR005 AVG TANK AGE
CODE



MEAN	2.387	STD ERR	0.291	MEDIAN	1.950
MODE	1.000	STD DEV	1.564		

VALID CASES 31 MISSING CASES 0

VAR015 CONDITION OF TANKS

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	1.	7	22.6	22.6	22.6
	2.	7	22.6	22.6	45.2
	3.	10	32.3	32.3	77.4
	4.	3	9.7	9.7	87.1
	5.	4	12.9	12.9	100.0
	TOTAL	31	100.0	100.0	

VAR015 CONDITION OF TANKS

```
CODE
     I
  1. ************************************ (      7)
     I
     I
     I
  2. ************************************ (      7)
     I
     I
     I
  3. ************************************************** (     10)
     I
     I
     I
  4. ***************** (      3)
     I
     I
     I
  5. ********************** (      4)
     I
     I
     I.........I.........I.........I.........I.........I
     0         2         4         6         8        10
     FREQUENCY
```

MEAN	2.677	STD ERR	0.234	MEDIAN	2.650
MODE	3.000	STD DEV	1.301		

VALID CASES 31 MISSING CASES 0

APPENDIX C

RAW DATA FILE

Raw Data File

```
0010 1 5 3 4 2 6 10 6 3 2 2 3 1 2 3
0020 36.7 4 4 2 2 .1 2 .5 .5 .5 .8 .3 .1 .1 .1 .4 4 4 4 3.5 1.5 3.5 .4
0030 3.5 1.4 14.7 0 1 .8 .1 0 2 0 .5 .2 .1 .1 .1 .1 .1 .2 .1 2 0 0 .8
0040 .1 0 .1 .1 2 0 .1 .1 1.3 1.3 .5 .5 .5 .1 .1 .1 .1 0 .1 .3 .5 .3 .1
0050 .1 1.5 .3 .1 .1 .1 .1 .1 .1 .1 .1 .1 .6 4.2 3 .6 3 0 .5 2.3 .2 2.3
0060 .25 .6 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 1 2 2 1 1 2 1 1 4 1 1 4
0070 4 1 4 1 1 1 1 1 1 2 2 1 1 4 4 1 1 1 1 1 1 4 1 1 1 1 1 1 1 1 1 1 1
0080 4 4 1 1 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 4 1 2 1 3 3 1
0090 2 4 3 3 1 5 0 0 2 1 3 1 1 3 2
0100 2.2 1.8 .3 .1 .1 .1 .2 .1 .1 .1 .2 .1 .1 .1 .2 .2 .3 .1 .2 .1 .1 .2
0110 .1 .2 .2 .2 .2 .1 .1 .1 .2 .2 .1 .1 .2 .1 .1 .1 .1 .1 .2 .1 .3 .2 .2
0120 .4 .3 .1 .1 .2 .5 .6 .1 .1 .3 .9 .4 .4 .1 .1 .1 .1 .2 .3 .3 .1 .1 .1
0130 .1 .1 .2 .1 .1 .4 .2 .1 .1 .1 .2 .1 .1 .3 1.3 2 .2 .8 6 .1 .2 .3 .2
0140 .4 .1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0150 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0160 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 2 0
0170 1 2 4 5 2 4 8 5 3 3 3 1 1 0 3
0180 2 .4 .2 .2 .2 .2 .5 .3 .1 .1 1.2 .3 .1 .5 .2 .4 1.3 .3 .7 .5 .2 .5
0190 .3 2.9 1.1 1 1 .1 .2 .2 .2 1 .4 1.1 1.1 3 1.1 1.1 .5 .5 .5 .2 1.1 1.1
0200 .2 .5 .2 .3 .3 .5 .5 0 .3 .3 .3 .1 .3 .3 .1 .2 .1 .3 .3 .3 .1 .1 .1
0210 .1 .1 .1 .7 0 0 .2 0 .1 .5 .4 .4 .1 .3 1.4 0 0 .5 1.4 2 0 1.1 .9 .5 .3 .5
0220 1 1 1 1 1 2 1 1 1 2 1 2 3 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 2
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0240 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0250 2 3 3 3 2 4 5 4 3 1 2 2 1 4 3
0260 1.4 1 .2 .2 .1 .3 .5 .2 .1 .1 .6 .1 .1 .3 .1 .5 5 .2 1.5 .3 8.2 .5
0270 .5 .3 .3 1.9 .5 .1 .1 .1 .2 .2 .1 .1 .1 .1 .5 .4 .4 .1 .2 .2 .2 .1 .5
0280 .7 .1 .1 .4 .3 .7 .4 .2 .1 .5 .4 1.2 .1 .1 .1 .1 .1 .1 .2 .2 .1 .2 .2
0290 .1 .1 .2 .1 .1 .2 .3 .3 .3 .3 .4 .2 .2 .2 .6 .6 .5 5.6 .6 .6 .6
0300 .3 .3 .5 .3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1
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0320 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0330 1 6 3 3 5 5 7 5 2 2 2 2 2 2 3
0340 1.5 1 1.5 1.5 2.1 2.1 .6 .4 1.1 .3 .3 1 .6 2.1 1.2 2.1 1 .6 3.5
0350 1.5 1.1 1.5 .6 3 2 .6 .6 .6 .6 .6 1 1.6 .7 .7 .7 .6 .6 .6 .7 .6 1.5
0360 .7 .8 .5 0 1.8 .6 .6 1 .3 .6 0 .6 .6 2.5 .6 .6 .6 .6 .6 .6 .6 .6 .6
0370 .6 .6 .6 .6 .6 .6 2.4 .6 .6 .6 .6 .6 .6 .6 1.5 .6 .6 .6 2.5 2.5 1.4 .4
0380 3.5 .6 1.5 1.8 .5 .3 2.1 2.1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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0410 1 1 1 1 1 1
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0430 .9 1.9 .5 1.5 2.8 5.3 3.3 .8 .5 1.6 .9 .6 .3 .4 1 .7 6.5 1.7 4.8
0440 .6 .8 1.2 .2 .9 2.3 1.4 .1 .1 .1 .3 .1 1.6 .3 .1 .3 1.1 .2 .2 .9 .8
0450 .3 .3 1.1 1.5 .2 .3 .1 .1 .2 .3 .5 0 .1 .7 .5 .3 .9 .9 .9 .1 .1 .1
0460 .4 .5 .3 .6 .5 .7 .2 .2 .7 0 0 1.7 0 .2 .2 .4 .5 .3 .6 1.3 .3 1.3 .3
0470 2.1 .5 .8 .4 .2 1 1.2 .1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
0480 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 2
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0600 2.2 1.7 .6 .3 .5 1 .8 .6 .5 0 1 0 0 1 .5 1.8 1.8 1 1 1 .5 .5 0 1.5
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0630 .3 .9 0 0 .3 0 .2 .2 .3 .5 .2 .5 .9 4.3 1.8 .8 3.2 1.5 1.8 3.8 .9
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0650 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 4 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
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0750 1 1 1 1 1 2 1 1 1 2 1
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0870 .1 .2 .8 .8 .6 .8 .5 .4 .2 .2 .2 .1 .1 .2 .2 .2 .1 .2 .2 .8 .2 .1
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0890 .6 .9 .8 .4 .3 .4 .3 .7 .7 .3 .6 .3 .3 .6 .5 .1 .3 .5 0 0 0 1.5
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1040 2.3 1.5 1.4 .6 2.1 2.1 3.1 1.5 1.1 2.1 1.1 .8 1.4 .8 1 1.1 .8 1.1 .3
1050 1.1 1.1 .6 .8 1.1 1.5 0 1.5 .5 .5 .5 .5 .9 0 .5 .5 2.1 1.8 1.4 .6 .5
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1070 .5 1.1 1.1 1.1 2.2 1.4 2.2 1.6 1.9 1.8 1 .5 1 1 1 1 1 1 1 1 1 1 1 1
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1100 1 1 1 1 1 1 1 1 1 1 1
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1120 1 .2 1 .5 0 0 0 0 .5 0 0 0 0 .1 0 .5 6 0 2 2 1 1 0 0 4 3 0 0 0 1
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1140 .2 .2 .1 .1 .1 .2 .1 .1 .1 .1 .2 .1 .5 .2 .2 .2 .2 .1 .1 .2 .2 .1
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1160 4 1 1 1 1 4 4 1 1 4 4 4 1 1 1 1 4 4 4 1 1 4 1 4 4 4 4 4 1 1 1 1 1 1
1170 0 4 4 1 1 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 1 1 1 2 1 1 1
1180 2 4 1 1 4 2 2 1
1190 1 6 1 3 3 8 5 5 4 2 5 3 2 3 4
1200 3 2 .5 .4 .7 .5 .6 1.2 1 .6 .5 .3 .3 .4 .3 1.2 1.1 .5 .5 .5 .5 1 .3
1210 1.8 .5 1 1 .5 .5 .3 .3 1 .5 1 1 1 .5 1 .6 .3 .3 .3 1 .3 1 1.8 .3 .3
1220 .8 .8 1.5 0 .4 .4 .6 .8 .4 .4 .2 .4 .2 .3 .3 0 .4 .4 .4 .4 .4 .3 .8
1230 .3 .4 .4 .6 .3 .3 1.1 .4 .1 .3 .2 0 0 0 0 0 0 0 0 .8 .8 0
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1250 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1
1260 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 1 0
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1290 4 .6 1.3 .2 12.2 .5 .4 .5 .1 .2 .3 .3 .9 .2 .4 .1 .2 .1 .1 1 1 .2 .2
1300 .9 .5 7.4 1 .6 .2 .1 1 1.8 0 .1 .1 1 1 1 1 .2 .1 .1 .1 .5 1 .9
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1470 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .3 1 1 .5 1 .5
1480 .5 .4 .2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1490 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1500 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1510 2 6 3 2 5 6 5 1 3 2 2 2 2 6 2
1520 2.2 3 4.2 1 1.3 4.3 4.7 4.7 .6 1.7 2.1 .6 .4 .4 .5 1 1.7 1.2 1.5
1530 1 .6 1.1 .5 1.1 1.5 1.5 1 .5 .5 .5 .2 2 1.4 .3 1.4 .5 .5 .5 1 .3
1540 .6 .6 .6 .6 0 1 .3 .3 2.1 .5 .5 .5 .5 .5 .8 .8 1.1 1.1 .3 .3 .1
1550 1.2 .3 .3 1.1 .4 .5 .2 .2 .5 0 .3 .3 .3 .3 .2 .5 1.1 .4 .2 .6 2.1
1560 1 1 .5 2 2 1 1 .5 2 1.5 .2 1 1 1 4 1 2 3 3 4 4 1 1 1 1 1 2 2 4 2
1570 2 2 1 1 2 1 2 2 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 4 2 1 1 1 1 1 1
1580 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1590 1 1 1 1 1 1 1 1 1 1 3 1
1600 2 4 1 2 5 7 5 7 1 1 2 2 1 4 3
1610 1.1 1.0 .3 .2 .8 .3 2.0 1.3 1.1 .5 .2 .5 .3 .2 .4 10.7 1.3 .1
1620 .3 .1 .1 .1 .1 .2 .1 .1 0 .1 .2 .5 .5 .3 .3 .1 3.9 .1 .1 .1 .1 .2
1630 .4 .1 20.0 .3 1.1 1.4 .6 1.2 2.2 .2 .2 .2 .1 .1 .1 .2 .3 .2 .5 .5
1640 .3 .9 .4 .6 .3 .2 .5 .6 1.2 .5 .2 .5 .5 .2 .5 .1 .2 .1 .5 .4 .3 .6
1650 0 .3 .4 .5 0 .2 .6 0 .4 .1 .2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1660 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1670 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1680 1 1 1 1 1 1 1 1
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1690 2 6 2 3 1 6 4 6 3 3 3 2 1 6 1
1700 .8 1.5 .6 .5 .5 .5 .5 .2 .2 .2 .6 .2 .1 .1 .1 .9 2.1 1.0 .8
1710 .8 .5 .8 .4 .2 1.1 1.2 .4 .4 .2 0 0 .5 .2 .1 .2 .2 .1 .1
1720 .1 1.1 .5 .3 .2 .1 .2 .5 .1 .1 .1 .2 .2 .1 .1 .1 .5 .2 .2 .2
1730 .5 .3 .2 .2 .2 .3 .2 .2 .3 .3 .3 .3 .3 .1 .3 .3 .3 .2 .3 .5
1740 .3 .3 .3 .3 1.8 1.0 .3 1.1 .8 1.1 1.8 .6 2.0 .9 .6
1750 2 1 1 1 2 2 2 2 2 2 1 2 2 1 2 2 2 1 2 2 2 2 2 1 2 2 2 2 4 4 2
1760 4 4 2 2 2 2 2 1 4 4 4 4 2 4 4 2 2 2 2 2 2 2 1 1 1 1 1 1 2 2 2 2
1770 2 1 1 2 2 1 2 2 2 2 2 2 1 1 1 2 2 2 1 1 1 1 1 2 2 1 1 1 1
1780 1 6 2 3 3 6 5 6 2 1 4 1 0 6 5
1790 .5 .1 .1 .1 .1 .1 .1 .1 .1 .1 .3 .1 .1 .1 .1 .1 .1 .1 .1
1800 .1 .1 .1 .1 .1 .1 .1 .3 .1 .1 .1 .1 .1 .2 .1 .2 .1 .1 .1 .1
1810 .3 .1 .1 .1 .1 .1 .1 .5 .1 .1 .2 .1 .3 .1 .1 .1 .2 .3 .5 .2 .1
1820 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .1 .3 .1 .1 .1 .1 .1 .1 .1
1830 1.5 .5 .5 .3 1.5 1.5 .5 .6 .5 .8 .5 .5 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1840 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1850 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1860 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1870 2 3 3 1 2 5 4 5 3 1 2 1 1 6 2
1880 0 1.0 .2 .2 .2 .2 .3 .6 .2 .2 .6 .1 .1 .3 .1 .5 17.3 .1 1.0
1890 .3 .8 .6 .1 .5 .4 1.5 .5 .1 .2 .3 .2 .2 .2 .2 .2 .2 .4 .4
1900 .5 .3 .2 .1 .2 .2 0 .8 .2 .2 .4 .4 .4 .2 .3 .3 .5 .5 .3 .4 .2
1910 .3 .3 .1 1.0 .2 .1 .3 .3 .2 .2 .2 .3 .3 .3 .2 .3 .2 .2 .2
1920 .3 .4 .7 1.4 2.0 1.7 .1 5.0 .8 .5 .6 .3 1.4 .4 .2
1930 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 1 1 1 1 1 1 1 1 1 1 1 1
1940 1 1 1 1 1 1 1 1 1 1 1 1 1 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1950 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1
1960 2 0 0 0 0 0 0 5 5 1 2 2 1 1 6 5
1970 1 .3 1 0 0 0 .8 0 0 0 .7 .3 0 .1 .2 1.0 4 .2 1.5
1980 .7 .2 .6 0 .7 .7 1.2 .2 .1 0 0 0 1 .1 .3 .4 .1 .2 .2
1990 .1 .2 .8 0 .4 0 0 .6
2000 0 0 .1 .5 .2 0 .2 .3 .3 .5 .1 .1 .1 .1 .1 0 0 0 .1 0 .1 0 .1 .1 .3
2010 0 .1 .8 0 0 .1 .6 .6 .1 .2 .8 0 0 .1 1.3 .4 .5 1.3 0 .7 .4 .4
2020 1 1 4 4 4 4 1 4 4 4 1 2 4 4 3 2 2 1 2 2 2 2 4 2 2 1 2 2 4 4 4
2030 1 2 2 2 1 2 2 1 2 1 4 1 4 4 1 4 4 1 1 1 4 1 1 1 1 1 1 1 1 4
2040 4 4 1 4 2 4 3 3 1 4 1 2 4 4 1 1 1 1 1 1 4 4 1 1 1 2 2 4 2 1 1
2050 2 6 3 2 1 6 5 1 4 2 1 2 1 6 1
2060 .8 .3 .2 .2 .7 .2 .7 .3 .3 .3 .2 .1 .1 .2 .2 .4 .7 .2 .6
2070 .3 .2 .4 .2 .5 .4 .8 .3 .2 .1 .2 .2 .2 .2 .3 .3 .2 .2 .1
2080 .2 .1 .4 .3 .3 .2 .4 .7 .2 .3 .8 .8 1.3 .3 .3 .3 .3 .7 .6
2090 .4 .2 .2 .2 .5 .3 .6 .6 .3 .7 .2 .2 .2 .7 .3 .5 .8
2100 .5 .4 .2 .6 .6 .2 .3 .7 .7 .7 .3 .6 .7 .9 .4 .3 .7 .7 .3
2110 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2120 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2130 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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2140 1 6 2 3 2 6 5 6 3 3 2 4 2 6 3
2150 .9 .3 .4 .3 .3 .2 .5 .5 .1 .1 .5 .1 .1 .3 .1 .4 16.3 .1 1.5
2160 .2 .2 .5 .2 .2 .4 1.5 .4 .1 .2 .3 .1 .2 .1 .1 .1 .1 .3 .3
2170 .4 .2 .1 .2 .2 .1 .3 .5 .2 .6 .2 .6 .7 0 .2 .2 .3 .2 .7 .3
2180 .6 .3 .3 .6 .3 .6 .2 .3 .2 0 .4 .3 .6 0 0 .5 0 0 .2 .6 .6 .2
2190 .2 .4 .8 .6 .4 .4 .7 .2 .7 .2 .7 0 .5 1 1 1 1 1 1 1 1 1 1 1
2200 1 1 1 2 3 1 1 1 1 1 1 1 1 1 1 1 1 2 1 2 2 1 1 1 1 1 1 1 1 1
2210 3 2 1 1 1 1 1 1 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 4 1 1 1 4 4 1
2220 4 4 1 3 1 1 1 1 1 1 1 1 1 1 2 1 1 4 1
2230 2 5 3 2 2 6 6 6 2 2 2 2 1 6 2
2240 1.2 1.6 1 .7 .6 1.1 1.1 .8 .5 1.1 1.1 .6 .6 1.1 .6 1.1 2.8 .9 1.5
2250 .9 1.6 .6 .5 1.5 .6 1.2 .6 .5 .5 .5 .5 1.1 0 .6 .6 1 .6 .6
2260 .9 .5 1 .7 .6 0 0 .6 .1 .1 .6 .5 .5 .5 .3 .3 .9 .5 .3 .3 .2 .1 .1
2270 .1 .1 .5 .3 .2 .1 .2 .2 .1 .9 .3 .3 .6 .3 .3 .3 .3 .3 .3 .3 .6
2280 .3 .3 .1 .6 .3 .3 .3 .1 .8 .5 .3 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2290 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 4 4 1
2300 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2310 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2320 1 6 3 3 1 6 14 6 1 1 2 4 3 6 2
2330 4 .3 .2 .2 .2 .3 .4 .5 .2 1 .3 .2 .2 .2 .2 .3 .5 .2 0
2340 0 .2 4 .2 3 .4 .7 .4 .4 .2 .2 .2 .3 .3 .2 .2 .2 .2 .2
2350 .2 .2 0 0 4 .7 0 1.3 .1 .1 .4 .2 .7 0 .1 .1 .5 .5 .7 0 .4
2360 .1 .1 .1 .1 .2 .3 .2 .1 .1 .1 .1 .1 0 0 .2 0 .1 .1 .3 .4
2370 .1 .1 .5 .7 1 .2 6 .4 1.1 1.7 .2 3.5 0 .2 1 1 1 1 1 1 1 1 1
2380 1 1 1 1 1 1 1 1 1 4 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2390 4 4 1 1 4 1 1 1 1 1 1 4 1 1 1 1 1 4 1 1 1 1 1 1 1 1 1 1 1 1
2400 4 4 1 4 1 1 1 1 1 1 1 1 1 1 2 2 2 2 1 4 1
2410 1 4 3 3 2 6 5 6 2 3 2 2 2 2 3
2420 4.7 1.8 1.8 .5 .5 .3 1 .3 .25 1 .5 .25 .25 .5 .5 .5 2 .5 1
2430 1 .8 .5 .3 2.3 1.8 1.5 1.3 .6 .5 .5 1 .6 .8 .5 .25 1 .6 .5
2440 .5 1.5 1.5 1.5 1.5 .5 0 1.3 .25 .3 .3 .3 .3 0 .25 .25 .25 .25
2450 .3 .25 .25 .25 .25 .25 .25 .25 .25 .25 .25 .25 .25 .25 .3
2460 .25 .25 .25 .25 .25 .25 .3 .25 .25 .25 .25 2 1.1 .5 1 0 .5 1.4
2470 1.2 .75 1.2 .9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2480 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 4 1 1 1 1 1 1 4 1 1 1
2490 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2500 1 1 1 1 1 1 1
2510 1 6 2 5 5 5 7 5 3 3 2 4 1 4 4
2520 3 2 10.7 .4 3 12 7.7 .4 .3 .6 1.5 .2 .1 .2 .5 .4 4.7 .1 2.2
2530 2.3 .3 .6 .5 1 3.7 1.9 .2 .5 1 .6 0 2.3 2 .7 .6 .6 .6 .6
2540 4.7 .6 3.8 .6 .4 .6 .1 1.2 .2 1 .3 4.7 3.7 3.7 .5 .5 2 2.1 1.2
2550 1.2 .5 .2 .1 .3 .1 .1 .6 .1 .3 .2 .3 .3 .6 .6 .6 .8 .4 .4 .4 .4
2560 1.5 .3 .6 1.5 2.4 2.4 .6 4.1 1.2 0 2 0 1.3 .6 .5 1 1 4 4 4 1 1 4
2570 1 4 1 1 4 4 1 1 1 4 1 1 1 1 4 1 1 1 1 4 4 4 1 1 1 1 1 1 1 1 1 1
2580 4 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 4 4 4 1 4 1 1 1 1 1 1 1 1
2590 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 4 1 4 1 1 1
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Raw Data File (continued)

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2600 2 5 3 0 1 6 5 5 1 1 2 3 1 6 1
2610 1.5 1 .2 .2 .3 .2 .6 1 .2 .2 .6 .2 .2 .5 .2 .5 20 .2 1
2620 .2 .1 .5 .3 .6 1.1 1.5 .5 .3 .3 .3 .2 .2 .2 .2 .2 .2 .4 .4
2630 .4 .2 .1 .1 .1 .1 0 .6 .1 .2 .4 .2 .4 .2 .1 .1 .5 .5 .1 .1
2640 .1 .1 .1 .1 .1 .2 .2 .1 .1 .1 .1 0 .3 .2 .1 .2 .2 .2 .2 .3
2650 .4 .2 .1 .2 2.1 1.5 .1 6 .3 .4 1 .2 3.5 0 .1 1 1 1 1 1 1 1
2660 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2670 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
2680 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 4 1 1 1 2 1 1 1 1
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APPENDIX D

COMPUTER PROGRAMS

```
0010**S,R(ZL) 1,8,16**,16
0020*!IDENT!WP1186,AFIT/LSG FRICK 79B
0030*!SELECT!SPSS/SPSS
0040RUN NAME!QUESTIONNAIRE ANALYSIS USING CONDESCRIPTIVE
0050VARIABLE LIST!VAR001 TO VAR201
0060INPUT FORMAT!FREEFIELD
0070N OF CASES!31
0080INPUT MEDIUM!CARD
0090MISSING VALUES!VAR001 TO VAR201(0)
0100VAR LABELS!VAR016,LUBRICATION/VAR017,RD WHEELS-IDLER-ROLLERS/
0110!VAR018,ARMS & HUBS/VAR019,SHK ABS & BFR SPRG/VAR020,TOR BARS/
0120!VAR021,SPROCKETS/VAR022,TRACKS/VAR023,TRK TEN & ADJ LINK/
0130!VAR024,ACCESS COVERS/VAR025,FENDERS & STW BOXES/
0140!VAR026,AIR CLEANER/VAR027,EXTERNAL TELEPHONE/
0150!VAR028,TOWPINTLE-HOOKS-LIFTING EYES/
0160!VAR029,LIGHTS/VAR030,T DECK-B DOORS-TRAVEL LOCK/
0170!VAR031,OIL COOLERS-SHROUD SEAL & AIR CLNR HOSES/VAR032,PWR PLANT/
0180!VAR033,OIL LEVELS/VAR034,ENGINE/VAR035,TRANSMISSION/
0190!VAR036,U JOINTS & FINAL DRIVE/VAR037,FUEL SYSTEM/VAR038,SEATS/
0200!VAR039,ELEC WIRING & COMPONENTS/VAR040,BATTERIES/
0210!VAR041,FIRE EXTG SYSTEM/VAR042,GAS PART FILTER SYSTEM/
0220!VAR043,DRIVER'S ESCAPE HATCH COVER/
0230!VAR044,DRIVER'S HATCH & PERISCOPES/
0240!VAR045,DRAIN VALVES/VAR046,HULL TURRET SEAL/
0250!VAR047,HYDRAULIC BRAKE SYSTEM/VAR048,PERSONNEL HEATER/
0260!VAR049,INTERIOR LIGHTS-RHEOSTATS-SWITCHES/
0270!VAR050,STRTR SWITCH-FUEL SHUTOFF-PURGE PUMP/
0280!VAR051,INSTRUMENTS-GAGES-WARNING LIGHT/VAR052,STEERING CONTROLS/
0290!VAR053,SHIFTING CONTROLS/VAR054,BRAKE CONTROLS/
0300!VAR055,GOVERNED SPEED & PERFORMANCE/VAR056,WHEEL HUBS/
0310!VAR057,SHOCK ABSORBERS/VAR058,LEAKS/VAR059,DECALS-STENCIL-PAINT/
0320!VAR060,MODIFICATIONS/VAR061,FINAL ROAD TEST/
0330!VAR062,GUN SHIELD COVER/VAR063,LOADER'S HATCH/
0340!VAR064,AMMO RACKS & STOWAGE BOXES/VAR065,MAIN ACCUMULATOR/
0350!VAR066,TURRET TRAVERSING & HYDRAULIC SYSTEM/
0360!VAR067,GRENADE LAUNCHER/VAR068,M36 COMMANDER'S PERISCOPE/
0370!VAR069,M32 GUNNER'S PERISCOPE/
0380!VAR070,BORE EVACUATOR CHAMBER/VAR071,GUN TUBE/
0390!VAR072,BREECH OPERATING MECHANISM/VAR073,BREECHLOCK CLSG MECH/
0400!VAR074,FIRING CONTACT/
0410!VAR075,REPLENSIHER ASSEMBLY/VAR076,EMERGENCY FIRING DEVICE/
0420!VAR077,HATCH ASSEMBLY/VAR078,CUPOLA ACCESS DOORS/
0430!VAR079,TERMINAL BOARD ASSEMBLY/
0440!VAR080,CUPOLA ASSEMBLY RING GEAR/VAR081,AZIMUTH LOCK ASSEMBLY/
0450!VAR082,CRADLE ASSEMBLY/VAR083,CUPOLA ATTACHING SCREWS/
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SPSS Condescriptive (continued)

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0460$VAR084,AZIMUTH GEAR BOX/VAR085,ELEVATION SCREW JACK/
0470$VAR086,ELECTRICAL PARTS/VAR087,M28C COMMANDER'S PERISCOPE/
0480$VAR088,M31 GUNNER'S PERISCOPE/
0490$VAR089,SIGHTING SYSTEM SUPER ELEVATION CK/
0500$VAR090,M31 PERISCOPE & M115 MOUNT/
0510$VAR091,INFINITY SIGHT M44C/VAR092,M105D TELESCOPE/
0520$VAR093,M17 RANGE FINDER/VAR094,BALLISTIC COMPUTER/
0530$VAR095,M13A1 ELEVATION QUADRANT/VAR096,M28A1 AZ INDICATOR/
0540$VAR097,SIGHTING SYSTEM/VAR098,PREINSPECTION HULL/
0550$VAR099,PREINSPECTION TURRET/VAR100,LOGBOOK CHECK/
0560$VAR101,PURGING ALL FIRE CONTROL OR OPTICS/
0570$VAR102,COMMO INSP & RPR/VAR103,STALL CK-IDLE TEST-NO LOAD TEST/
0580$VAR104,POWER PACK INSTALLATION/VAR105,COMMO TEST/
0590$VAR106,FIRE CONTROL SYNCHRONIZATION/VAR107,BORE SCOPE & PULLOVER/
0600$VAR108,LOGBOOK UPDATE & SERV COMPLETION
0610CONDESCRIPTIVE$VAR016 TO VAR108
0620STATISTICS$ALL
0630READ INPUT DATA
0640$:SELECTA:LAF2
0650FINISH
0660$:ENDJOB
```

```
0010$$S,R(ZL) :,8,16$$,16
0020$:IDENT:WP1196,AFIT/LSG FRICK 798
0030$:SELECT:SPSS/SPSS
0040RUN NAME:QUESTIONNAIRE ANALYSIS USING FREQUENCIES
0050VARIABLE LIST:VAR001 TO VAR201
0060INPUT FORMAT:FREEFIELD
0070N OF CASES:31
0080INPUT MEDIUM:CARD
0090VAR LABELS:VAR001,MAJOR COMMAND/VAR002,BMO EXPERIENCE/
0100:VAR003,MAINT PERSONNEL EXPERIENCE/VAR004,CREW EXPERIENCE/
0110:VAR005,AVG TANK AGE/VAR006,NUMBER OF TANKS SERV SIMUL/
0120:VAR009,FACILITIES CONSTRAINTS/VAR010,SCHD SERV AS REPAIR TIME/
0130:VAR011,ADEQUACY OF 20 MANUAL/VAR012,CLASS IX CONSTRAINTS/
0140:VAR013,ADVANCE INSPECTION/VAR014,CLASS IX LEAD TIME/
0150:VAR015,CONDITION OF TANKS/VAR109,LUBRICATION/
0160:VAR110,RD WHEELS-IDLER-ROLLERS/VAR111,ARMS & HUBS/
0170:VAR112,SHK ABS & RPR SPRG/VAR113,TOR BARS/
0180:VAR114,SPROCKETS/VAR115,TRACKS/VAR116,TRK TEN & ADJ LINK/
0190:VAR117,ACCESS COVERS/VAR118,FENDERS & STW BOXES/
0200:VAR119,AIR CLEANER/VAR120,EXTERNAL TELEPHONE/
0210:VAR121,TOWPINTLE-HOOKS-LIFTING EYES/
0220:VAR122,LIGHTS/VAR123,T DECK-B DOORS-TRAVEL LOCK/
0230:VAR124,OIL COOLERS-SHROUD SEAL & AIR CLNR HOSES/
0240:VAR125,PWR PLANT/VAR126,OIL LEVELS/VAR127,ENGINE/
0250:VAR128,TRANSMISSION/VAR129,U JOINTS & FINAL DRIVE/
0260:VAR130,FUEL SYSTEM/VAR131,SEATS/
0270:VAR132,ELEC WIRING & COMPONENTS/VAR133,BATTERIES/
0280:VAR134,FIRE EXTG SYSTEM/VAR135,GAS PART FILTER SYSTEM/
0290:VAR136,DRIVERS ESCAPE HATCH COVER/
0300:VAR137,DRIVERS HATCH & PERISCOPES/
0310:VAR138,DRAIN VALVES/VAR139,HULL TURRET SEAL/
0320:VAR140,HYDRAULIC BRAKE SYSTEM/VAR141,PERSONNEL HEATER/
0330:VAR142,INTERIOR LIGHTS-RHEOSTATS-SWITCHES/
0340:VAR143,STRTR SWITCH-FUEL SHUTOFF-PURGE PUMP/
0350:VAR144,INSTRUMENTS-GAGES-WARNING LIGHT/VAR145,STEERING CONTROLS/
0360:VAR146,SHIFTING CONTROLS/VAR147,BRAKE CONTROLS/
0370:VAR148,GOVERNED SPEED & PERFORMANCE/VAR149,WHEEL HUBS/
0380:VAR150,SHOCK ABSORBERS/VAR151,LEAKS/VAR152,DECALS-STENCIL-PAINT/
0390:VAR153,MODIFICATIONS/VAR154,FINAL ROAD TEST/
0400:VAR155,GUN SHIELD COVER/VAR156,LOADERS HATCH/
0410:VAR157,AMMO RACKS & STOWAGE BOXES/VAR158,MAIN ACCUMULATOR/
0420:VAR159,TURRET TRAVERSING & HYDRAULIC SYSTEM/
0430:VAR160,GRENADE LAUNCHER/VAR161,M36 COMMANDERS PERISCOPE/
0440:VAR162,M32 GUNNERS PERISCOPE/
0450:VAR163,BORE EVACUATOR CHAMBER/VAR164,GUN TUBE/
0460:VAR165,BREECH OPERATING MECHANISM/VAR166,BREECHLOCK CLSG MECH/
0470:VAR167,FIRING CONTACT/
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0480#VAR168,REPLENISHER ASSEMBLY/VAR169,EMERGENCY FIRING DEVICE/
0490#VAR170,HATCH ASSEMBLY/VAR171,CUPOLA ACCESS DOORS/
0500#VAR172,TERMINAL BOARD ASSEMBLY/
0510#VAR173,CUPOLA ASSEMBLY RING GEAR/VAR174,AZIMUTH LOCK ASSEMBLY/
0520#VAR175,CRADLE ASSEMBLY/VAR176,CUPOLA ATTACHING SCREWS/
0530#VAR177,AZIMUTH GEAR BOX/VAR178,ELEVATION SCREW JACK/
0540#VAR179,ELECTRICAL PARTS/VAR180,M28C COMMANDERS PERISCOPE/
0550#VAR181,M31 GUNNERS PERISCOPE/
0560#VAR182,SIGHTING SYSTEM SUPER ELEVATION CK/
0570#VAR183,M31 PERISCOPE & M115 MOUNT/
0580#VAR184,INFINITY SIGHT M44C/VAR185,M105D TELESCOPE/
0590#VAR186,M17 RANGE FINDER/VAR187,BALLISTIC COMPUTER/
0600#VAR188,M13A1 ELEVATION QUADRANT/VAR189,M28A1 AZ INDICATOR/
0610#VAR190,SIGHTING SYSTEM/VAR191,PREINSPECTION HULL/
0620#VAR192,PREINSPECTION TURRET/VAR193,LOGBOOK CHECK/
0630#VAR194,PURGING ALL FIRE CONTROL OR OPTICS/
0640#VAR195,COMMO INSP & RPR/VAR196,STALL CK-IDLE TEST-NO LOAD TEST/
0650#VAR197,POWER PACK INSTALLATION/VAR198,COMMO TEST/
0660#VAR199,FIRE CONTROL SYNCH/VAR200,BORE SCOPE & PULLOVER/
0670#VAR201, LOGBOOK UPDATE & SERV COMPLETION
0680VALUE LABELS#VAR001 (1)FORSCOM (2)USAREUR (3)USARPAC (4)OTHER/
0690#VAR002 (1)0-6 MONTHS (2)6-12 MONTHS
0700#(3)12-18 MONTHS (4)18-24 MONTHS
0710#(5)24-36 MONTHS (6)OVER 36 MONTHS/
0720#VAR003 TO VAR004 (1)MORE EXPERIENCED
0730#(2)SLIGHTLY MORE EXPERIENCED (3)ABOUT THE SAME
0740#(4)SLIGHTLY LESS EXP.
0750#(5)LESS EXPERIENCED/ VAR005 (1)0-2 YEARS (2)2-4 YEARS
0760#(3)4-6 YEARS (4)6-8 YEARS (5)8-10 YEARS
0770#OVER 10 YEARS/ VAR009,VAR012
0780#(1)MAJOR CONSTRAINT (2)MODERATE CONSTRAINT (3)MINOR CONSTRAINT
0790#(4)NO CONSTRAINT/ VAR010 (1)MOST (2)MODERATE
0800#(3)SMALL AMOUNT (4)NONE/
0810#VAR011 (1)TOTALLY ADEQUATE (2)VERY ADEQUATE (3)SLIGHTLY ADEQUATE
0820#(4) SLIGHTLY INADEQUATE (5)VERY INADEQUATE (6)TOTALLY INADEQUATE/
0830#VAR013 (1)NO INSPECTION (2)ONE WEEK (3)TWO WEEK (4)THREE WEEKS
0840#(5)FOUR WEEKS (6)FIVE WEEKS (7)SIX WEEKS (8)SEVEN WEEKS PLUS/
0850#VAR109 TO VAR201 (1)QUARTERLY (2)SEMIANNUALLY
0860#(3)ANNUALLY (4)DELETE/VAR001 TO VAR201 (0)NO RESPONSE
0870FREQUENCIES#GENERAL=VAR001 TO VAR006,VAR009 TO VAR015,
0880#VAR109 TO VAR201
0890OPTIONS#3,8,9
0900STATISTICS#ALL
0910READ INPUT DATA
0920$:SELECTA:LAF2
0930FINISH
0940$:ENDJOB
```

```
0010GEN,FRICK,THESIS,7,28,1979,11,1,6,(11)60,S,,1,(19)E*
0020RES,1/TURRET,2,9,13,16,36,57*
0030RES,2/HULL,6,79,42,49*
0040QUE,65,5,5*CHANGE TO 4,4 TO RUN 5 TANKS
0050REG,1,1,1,D,M*
0060VAS,1,1,IN,1*
0070QUE,2,0,5*
0080QUE,80,0,5*
0090QUE,3,0,5*
0100QUE,4,0,5*
0110QUE,5,(10)7*
0120QUE,6,(10)7*
0130MAT,7,1,5/8,6*
0140STA,8,1,1,D,I*
0150QUE,66,(10)9*
0160ALL,9,POR,1,1,66/10*
0170REG,10,1,1*
0180FRE,11,D,1,1,9,13,16,36,57*
0190QUE,12,(10)20*
0200QUE,67,(10)13*
0210ALL,13,POR,1,1,67/14*
0220REG,14,1,1*
0230FRE,15,D,1,1,9,13,16,36,57*
0240QUE,70,0,6,(10)16*
0250ALL,16,POR,1,1,70/17*
0260REG,17,1,1*
0270FRE,18,D,1,1,9,13,16,36,57*
0280QUE,19,(10)20*
0290MAT,20,1,12/69,19*
0300QUE,69,(10)34*
0310QUE,68,(10)79*
0320ALL,79,POR,2,1,68/21*
0330REG,21,1,1*
0340STA,24,1,1,D,I*
0350STA,25,1,1,D,I*
0360STA,26,1,1,D,I*
0370STA,27,1,1,D,I*
0380REG,28,1,1*
0390REG,29,1,1*
0400REG,30,1,1*
0410FRE,31,D,2,1,79,42,49*
0420QUE,32,(10)34*
0430MAT,34,1,69/35,32,22,23*
0440QUE,76*
0450QUE,22,(10)34*
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0460QUE,77*
0470QUE,23,(10)34*
0480STA,35,1,1,D,I*
0490QUE,71,(10)36*
0500ALL,36,POR,1,1,71/37*
0510REG,37,1,1*
0520REG,38,1,1*
0530STA,39,1,1,D,I*
0540FRE,40,D,1,1,9,13,16,36,57*
0550QUE,41,(10)47*
0560QUE,72,(10)42*
0570ALL,42,POR,2,1,72/43*
0580REG,43,1,1*
0590STA,44,1,1,D,I*
0600FRE,45,D,2,1,79,42,49*
0610QUE,46,(10)47*
0620MAT,47,1,41/48,46*
0630STA,48,1,1,D,I*
0640QUE,73,(10)49*
0650ALL,49,POR,2,1,73/51*
0660REG,51,1,1*
0670STA,52,1,1,D,I*
0680FRE,53,D,2,1,79,42,49*
0690QUE,54,(10)55*
0700QUE,74*
0710QUE,50,(10)55*
0720MAT,55,1,54/56,50*
0730STA,56,1,1,D,I*
0740QUE,75,(10)57*
0750ALL,57,POR,1,1,75/58*
0760REG,58,1,1*
0770REG,59,1,1*
0780FRE,60,D,1,1,9,13,16,36,57*
0790QUE,61,(10)63*
0800QUE,78*
0810QUE,62,(10)63*
0820MAT,63,1,61/64,62*
0830SIN,64,6,(6)I*CHANGE TO 64,5 TO RUN FIVE TANKS
0840ACT,65,1*
0850ACT,1,2*
0860ACT,2,3,NO,1,1*
0870ACT,1,80*
0880ACT,80,4,NO,2,2*
0890ACT,3,5,NO,3,4,1*
0900ACT,4,6,NO,3,3,1*
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0910ACT,8,66*
0920ACT,10,11,NO,6,6,1*
0930ACT,11,12*
0940ACT,8,67*
0950ACT,14,15,NO,7,7,1*
0960ACT,15,70*
0970ACT,17,18,NO,12,12*
0980ACT,18,19*
0990ACT,8,68*
1000ACT,21,24,NO,8,8*
1010ACT,24,25,NO,13,13*
1020ACT,25,26,NO,14,14*
1030ACT,26,27,NO,15,15*
1040ACT,27,28,NO,18,18*
1050ACT,28,29,NO,19,19*
1060ACT,29,30,NO,21,21*
1070ACT,30,31,NO,22,22*
1080ACT,31,32*
1090ACT,8,76*
1100ACT,76,22,NO,9,9*
1110ACT,8,77*
1120ACT,77,23,NO,10,10*
1130ACT,35,71*
1140ACT,37,38,NO,23,23*
1150ACT,38,39,NO,25,25*
1160ACT,39,40,NO,27,27*
1170ACT,40,41*
1180ACT,35,72*
1190ACT,43,44,NO,24,24*
1200ACT,44,45,NO,26,26*
1210ACT,45,46*
1220ACT,48,73*
1230ACT,51,52,NO,28,28*
1240ACT,52,53,NO,30,30*
1250ACT,53,54*
1260ACT,48,74*
1270ACT,74,50,NO,29,29*
1280ACT,56,75*
1290ACT,58,59,NO,32,32*
1300ACT,59,60,NO,33,33*
1310ACT,60,61,NO,34,35*
1320ACT,56,78*
1330ACT,78,62,NO,34,34*
1340PAR,1,1.55,.2,4.3,1.1*TASK D1
1350PAR,2,1.21,.2,3,.72*TASK D2
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1360PAR,3,.47,.1,2,.39*TASK D3
1370PAR,6,2.16,.1,6,1.68*TASK D4
1380PAR,7,1.67,.4,10.3,1.91*TASKS 44-47
1390PAR,8,12.03,1.3,91.8,18.57*TASKS 2-14
1400PAR,9,3.87,.2,36.7,7.77*TASK 1
1410PAR,10,1.27,.3,6,1.198*TASK D5
1420PAR,12,7.28,1.8,29.1,6.62*TASKS 51-68
1430PAR,13,5.57,.2,30.7,6.99*TASKS 16-16A
1440PAR,14,.4,.1,1.5,.37*TASK 15
1450PAR,15,.64,.1,4,.88*TASK 17
1460PAR,18,3.37,.2,18.2,3.89*TASKS 18-19
1470PAR,19,.83,.1,2.2,.6*TASK D6
1480PAR,21,9.16,1.1,53.3,10.71*TASKS 20-29
1490PAR,22,1.43,.2,5.7,1.21*TASK D7
1500PAR,23,1.62,.3,8.6,1.85*TASKS 48-50
1510PAR,24,4.84,.8,22.4,5.18*TASKS 30-37
1520PAR,25,3.5,1,13.4,2.77*TASKS C1-C11
1530PAR,26,.55,.1,2,.51*TASK 38
1540PAR,27,.89,.1,3,.75*TASK C12
1550PAR,28,4.47,.5,34.8,7.77*TASKS 39-42
1560PAR,29,.56,.1,1.9,.43*TASK D8
1570PAR,30,.99,.3,2.1,.53*TASK 43
1580PAR,32,1.21,.2,3.5,.87*TASK D9
1590PAR,33,.69,.1,2.1,.45*TASK D10
1600PAR,34,.54,.1,2.1,.43*TASK D11
1610FIN*
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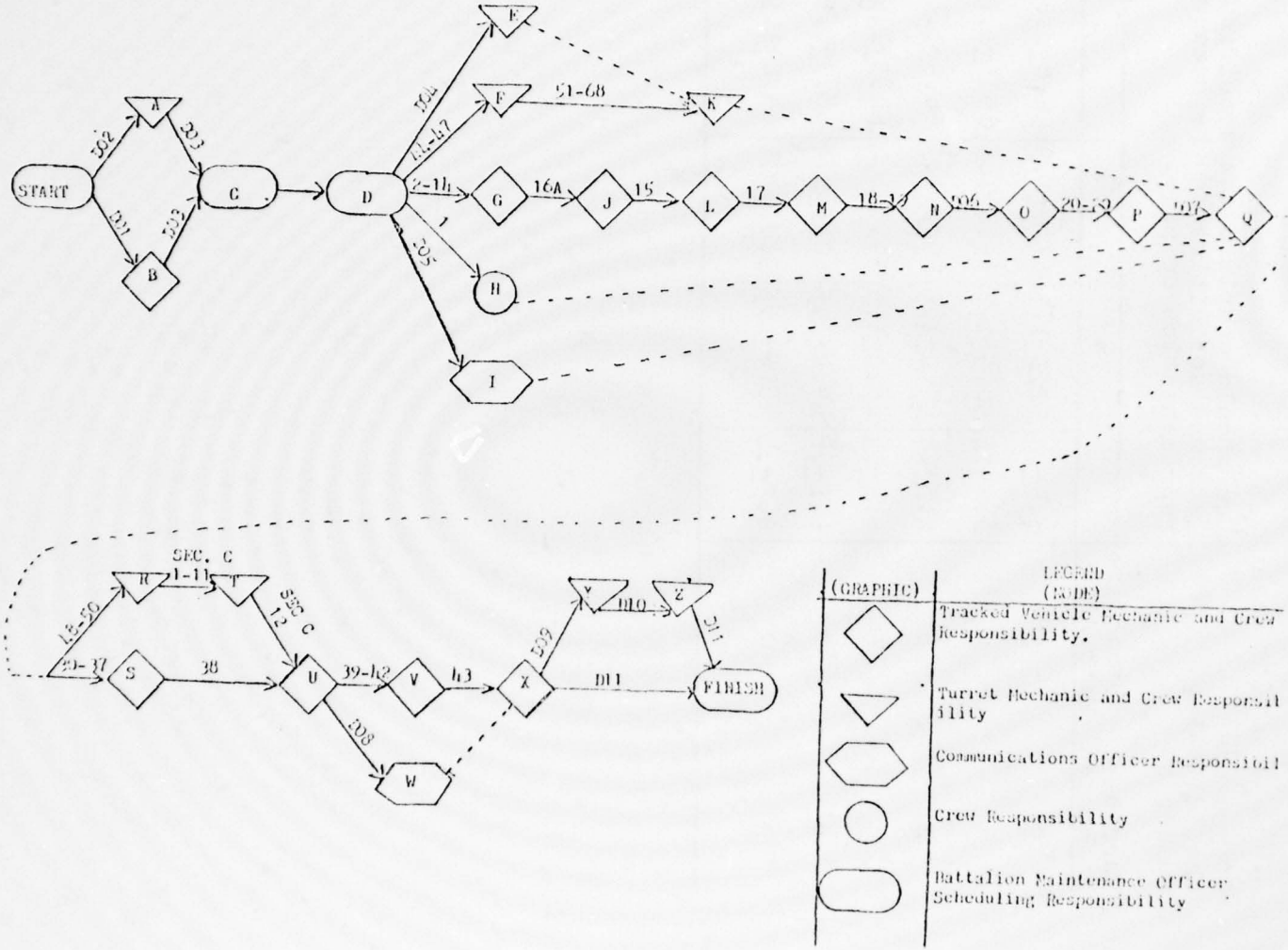
APPENDIX E

NETWORK RECOMMENDATION

TABLE E-1 - Milestone Planning Chart

If you use the following number of		You should complete the specified lettered activities on the network representation on page:				
Turret Mechanics	Automotive Mechanics	D	Q	U	X	Finish
2	5	6.5±.4	52.7±1.7	67.6±1.5	76.8±1.6	129.7±3.8
3	5	6.5±.4	50.5±1.7	65.4±1.5	75.8±1.7	129.7±4.0
2	6	6.5±.4	49.2±1.6	60.2±1.5	66.9±1.6	92.0±3.2
3	6	6.4±.4	48.3±1.5	59.4±1.4	64.3±1.4	90.8±3.4
2	7	6.6±.4	49.4±1.5	60.5±1.5	68.3±1.5	92.4±3.2
3	7	6.5±.4	48.6±1.5	56.7±1.5	63.6±1.5	92.5±3.2

PICTORIAL NETWORK
(Numbers correspond to section A-D of the questionnaire)



LEGEND

(GRAPHIC)	(SYMBOL)
◇	Tracked Vehicle Mechanic and Crew Responsibility.
▽	Turret Mechanic and Crew Responsibility
⬡	Communications Officer Responsibility
○	Crew Responsibility
▭	Battalion Maintenance Officer Scheduling Responsibility

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Captain Frick was commissioned through the Army ROTC program after receiving his Bachelor of Science degree in mechanized agriculture at South Dakota State University. After completing the Armor Officer Basic Course, Captain Frick was assigned to the 3rd Squadron 4th Cavalry, 25th Infantry Division and later to the 1st Battalion 63rd Armor, 1st Infantry Division. Captain Frick has served as a platoon leader, executive officer, maintenance officer, a tank company commander, and attended the Field Artillery Officer's Advanced Course. At AFIT, Captain Frick was a member of Sigma Iota Epsilon. After graduation, Captain Frick will serve as a supply management officer in Germany.

Captain Sasser was commissioned through the Army Officer Candidate School at Fort Benning, Georgia after receiving his Bachelor of Arts degree in chemistry from West Georgia College. After completing the Infantry Officer Basic Course, Captain Sasser was assigned as an instructor at the Infantry School at Fort Benning. Captain Sasser was next assigned to the 3rd Infantry Division. Captain Sasser has served as a brigade chemical officer, assistant brigade operations officer, executive officer, supply officer, a heavy equipment maintenance company commander and attended the Ordnance Officer's Advance Course. At AFIT, Captain Sasser was a member of Sigma Iota Epsilon. After graduation, Captain Sasser will serve as an instructor at the U.S. Army Logistics Center, Fort Lee, Virginia.